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Retraction

Retracted: Application of Intelligent Sensor Network in the Assessment of Table Tennis Teaching and Training Intensity, Training Volume, and Physical Fitness

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] H. Zhang, "Application of Intelligent Sensor Network in the Assessment of Table Tennis Teaching and Training Intensity, Training Volume, and Physical Fitness," *Journal of Sensors*, vol. 2022, Article ID 4553644, 6 pages, 2022.

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Research Article

Application of Intelligent Sensor Network in the Assessment of Table Tennis Teaching and Training Intensity, Training Volume, and Physical Fitness

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Sensor technology has been deeply into the sports industry, with the help of sensors to monitoring and collection data for the physical training in real-time. In table tennis, wearable sensors can record the amount of training, movement essentials, and the number of strokes of both hands and assist in the testing and evaluation of table tennis. This paper analyzes the application of wearable sensors in table tennis training activities and the details of signal collection and feature extraction. At the same time, machine learning technology often used to recognize and test table tennis training data, and a support vector machine (SVM) is one of the representative classifiers. Applying the processed signal data to the classification and testing of SVM can effectively identify the movement and evaluate the training effect and athletes' physical fitness. The integration of intelligent sensors and table tennis can effectively improve the evaluation efficiency and quality in the process of teaching and training.

1. Introduction

Rapid progress of sensor technology, research of actions, and behaviors in sports is critical for the management and organization of traditional sports training competition and competitive sports [1, 2]. In sports training, the amount of training, physical fitness, and the mastery of action essentials of athletes directly affect the training results and ultimate results of athletes. Therefore, with the help of intelligent sensor technology, comprehensively recording athletes' training volume and actions can help athletes quickly improve training results.

Chinese table tennis has great influence in the world, and table tennis skills are improving day by day [3]. In training and competition, table tennis has the characteristics of small size and fast speed. The movements of athletes are mostly variable, but they have their own characteristics. In professional table tennis training, the coach will carefully analyze the opponent's action characteristics in advance of the video data. Collect athletes' training, physical fitness, and competition data and adjust training strategies in time according to opponents' attack and defense weaknesses. For example, intelligent sensors such as wearable devices or videos are commonly used in teaching and training.

Obviously, sensor networks have become the representative technology of the current era. In residential life, industrial production, sports training, and scientific research, sensor networks are everywhere. The sensor can monitor the surrounding information and output it in the form of electrical signals. These electrical signals express corresponding laws. Of course, it can also be output in other data forms [4]. Sensor networks integrate many technologies, such as obtaining information, processing signals, processing data, and recording. Wireless sensors are often employed devices.

Wireless sensor network (WSN) can estimate physical quantities and convert them into signals read by observers or instruments. Sensors in WSN acquire input information, store information, and transform data and transmit it to other devices. In the research of motion recognition, acceleration sensor belongs to a kind of wearable sensor [5, 6]. Draw support from their low energy consumption, small

Table 1: Categories of sensors.

Categories	Sensors
Physical sensor	Acceleration sensor, temperature sensor, infrared light sensor, noise sensor
Chemical sensor	Gas sensor, humidity sensor
Biosensor	Respiratory sensor

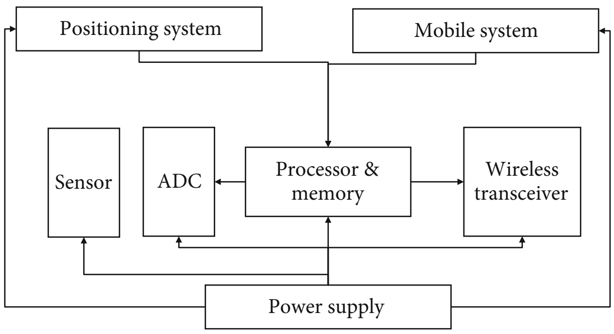

Figure 1: Operating principle of wireless sensor.

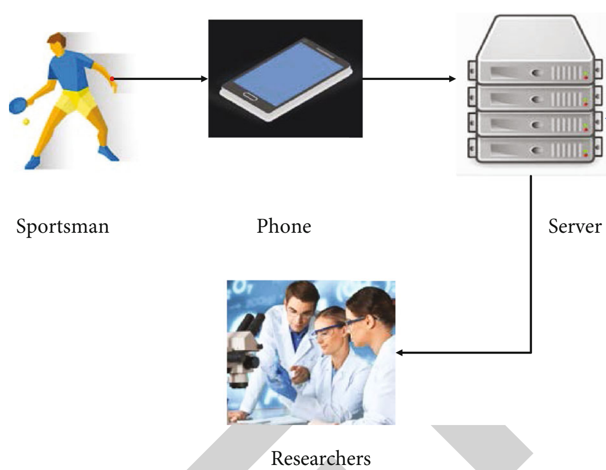

Figure 2: Operating principle of wearable sensor.

size, and low cost, wearable sensors are purchased and put into use by many training institutions.

In table tennis teaching and training, the application of acceleration sensing to the training process is divided into two links, namely, motion feature extraction, feature selection, and recognition algorithm. The acceleration sensor displays and analyzes the training times, hitting action, and swing action from the physical characteristics of the signal and the characteristics of human motion. Accurately recording and identifying athletes' data plays an important role in improving the training results of table tennis.

2. Related Work

2.1. Sensors and Sports. Sensor technology can be distinguished according to three modes. The first generation is structural sensors, which use the changes of structural parameters to sense and convert signals. The first generation has a significant structural feature, that is, structural sensors. The acquisition and processing of signals are adjusted by parameters, and the more representative is the resistance strain sensor. The second is solid-state sensors. Considering the unique properties of various materials, semiconductor or magnetic materials are selected. Behind them, thermoelectric effect and photosensitive effect are used, respectively. Next, comes the intelligent sensors, which have the ability of self-detection and signal processing, and can also well adapt to external conditions. The intelligent sensor has achieved a relatively intelligent mode, integrated with the network, and realized the memory and measurement work. As shown with Table 1, sensors can be generally divided into physical, chemical, and biological sensors.

With the increasing importance of sports and science and technology, sensor technology has been successfully applied to sports training, physiological and biochemical monitoring, and competition referee system (see Figure 1). As for the research on the application of sensors in physical training, Billiet et al. carried out the experiment on the relationship between human motion acceleration and energy consumption earlier [7]. The piezoresistive multiaxis acceleration sensing device is used to record the motion acceleration of body, such as walking or running. And the relationship between the obtained acceleration value and human motion energy consumption is explored [8]. Under the promotion of social informatization and intellectualization, sports have achieved great strides in sports informatization. Yu and Pan pointed out that the real-time sports data monitoring network has become the core of sports informatization, which can achieve the purpose of quickly obtaining data [9]. By extracting information from a large number of data that is conducive to the scientific management of athletes, we can make scientific sports training management decisions.

In golf, the sensor can monitor the technical action of swing. Ueda et al. assembled the gyroscope on the head, arm, shoulder, spine, and medulla to analyze the sports technology diagnosis of golf swing. The research results show that the golf technology quantitative analysis system formed by using sensor equipment is feasible and can effectively monitor the formation of swing movements [10].

There are many kinds of MEMS sensors. For tennis sports, we can complete the collection of sports data through the design combined with tennis rackets. For the sensor element, it can record the speed change of the racket during the player's swing, measure the acceleration of the carrier, reflect the speed parameters during the swing, and judge the specific position of the ball touching the racket, as well as the vibration of the racket. The gyroscope sensing part can record the direction and trajectory of the player's swing,

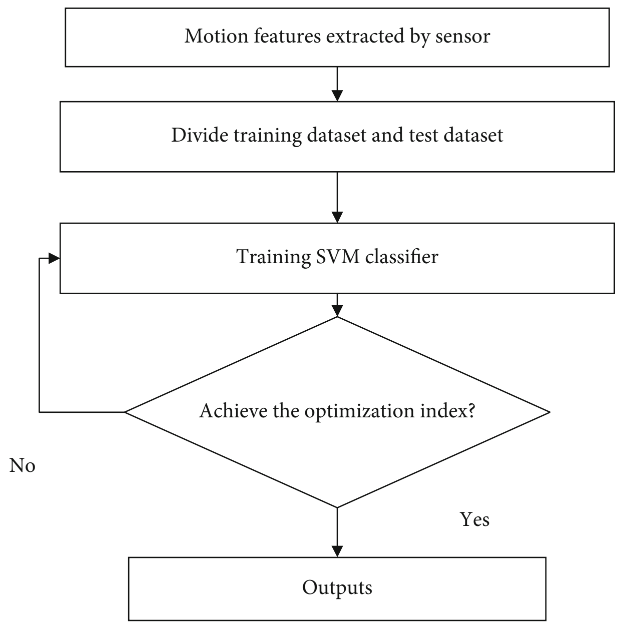

Figure 3: Training SVM classifier with signal data collected by wearable sensors.

combined with the speed change curve in the process of hitting the ball [11].

Wearable sensors are the general name of all sensors that can be conveniently arranged on the human body by wearing or carrying. The human motion recognition method based on wearable sensors collects human motion, physiological, and other information through sensors to complete the analysis and recognition of human motion [12, 13]. It can effectively collect the training times and hitting process parameters without imposing restrictions on the players' hitting position and hitting times on the court, which is conducive to the quantitative evaluation of training intensity, training volume, and athletes' physical function. Wearable sensors have incomparable advantages over traditional high-speed photography.

2.2. Research on Sensor in Table Tennis. In the teaching and training of table tennis, intelligent sensors are used to collect the inertia signals and physiological signals of athletes, to identify the swing and hitting movements, and to record the exercise intensity.

The University of Science and Technology of China studies the problem of table tennis motion recognition through two accelerometers placed on the arms of table tennis players. In the feature extraction stage, researchers use wavelet transform to extract the frequency domain information of actions and use ant colony algorithm to screen the features. Finally, the SVM algorithm is used to classify the extracted action feature data. The table tennis action recognition system developed by him can recognize the three actions of attacking, rubbing and pushing, and blocking. This method has achieved good results in a small range of people, but its generalization ability needs to be improved [14]. When multiple actions overlap, the recognition rate of this method will decrease significantly.

Ma has established an independent database for big data of wireless sensor networks to timely update table tennis competition data [15]. The proposed analysis system is used to simulate the table tennis game, and the targeted suggestions are put forward.

Tabrizi et al. established a low-cost and intelligent hitting and direction data set to detect and evaluate. IMU is installed in the center of table tennis racket. Table tennis novices and professional players are the research objects, respectively, and three table tennis professional coaches participate in it [16]. In this work, 1570 samples were collected as the supporting data of the system.

Using wearable sensors, researchers can obtain environmental, inertial, position, and physiological signal information [17, 18], as shown in Figure 2. Environmental information includes temperature, humidity, and light. Environmental information can provide a priori information of the scene for human action recognition. For example, using sensors that can monitor light and audio to predict human behavior, it can infer whether the monitored object is in a certain motion state by detecting the light and audio level in the environment [19, 20]. The sensor for acquiring inertial information is generally composed of accelerometer and gyroscope, which is the most widely studied action signal acquisition device. Inertial measurement units can be used to measure the linear acceleration and angular velocity of limbs in three-dimensional space, such as running or falling. Wearable devices have an increasingly large demand for positioning, which is used to infer a person's behavior. Physiological signals include heartbeat, respiratory rate, and electrocardiogram. Silvano et al. gave physiological signals to judge human actions and behaviors, used five three-axis acceleration sensors and a heart rate detector to detect human behaviors, and took the data of the heart rate detector as an auxiliary evaluation index of action classification, thus effectively reducing the misclassification rate of actions [21].

For the recognition and evaluation of signals collected by sensors, machine learning algorithms, such as decision tree, SVM, and neural network, are important technologies [22], and PCA is often used to reduce the dimension of collected signal data [23].

3. Table Tennis Teaching Training and Evaluation Based on Acceleration Sensor

For table tennis teaching and training based on wearable sensors, the collected signal data needs the combination of feature extraction and classification algorithm. According to the hardware equipment, recognition actions, and application scenarios, the theoretical support framework is established. The system framework has some similarities, including data collection, noise elimination, feature extraction, training classifier, and action recognition. Among them, the signal collection is directly completed by wearable sensors.

3.1. Signal Preprocessing. For the raw data collected by wearable sensors, in the data processing stage, we should

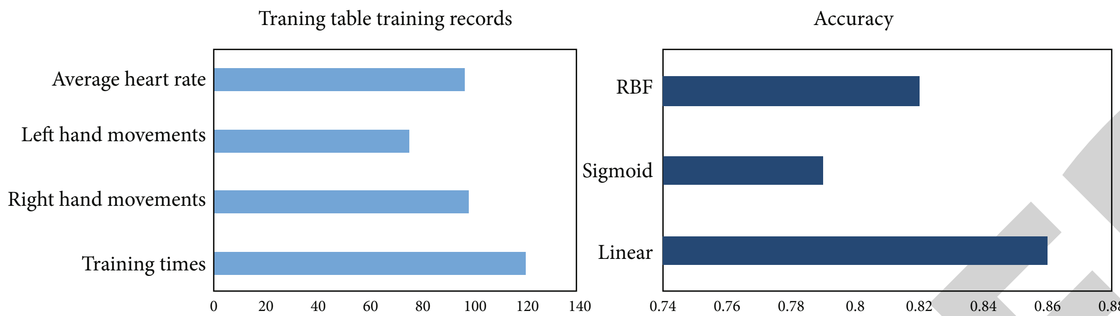

Figure 4: Table tennis training and evaluation results based on wearable sensors.

eliminate various noise data as much as possible and retain the feature points of the original data as much as possible or enlarge some necessary feature points.

Filtering is a commonly used low channel signal processing method, and its mathematical principle is as follows [24].

$$\text{Gravity}(k) = \alpha * \text{Gravity}(k) + (1-\alpha) * \text{Value}(k), \quad (1)$$

where $\text{Value}(k)$ represents the acceleration in three directions of X, Y, Z.

3.2. Feature Extraction. Feature extraction of motion acceleration signal is a very important step in the process of signal recognition. Find the potential characteristics of the action acceleration signal and use this feature to distinguish it from other signals. Whether the feature extraction is reasonable or not plays an important role in the realization of the action acceleration signal recognition system.

Action signals include physical characteristics and human kinematic characteristics [25]. Among them, whether the feature attributes of actions are selected properly or not will directly affect the recognition accuracy and real-time performance of the classifier. When extracting physical characteristics, power spectrum analysis, wavelet transform, and fast Fourier transform are used. When extracting motion features, average value, entropy, and vector value are used.

3.3. Training Classifier. After preprocessing the extracted features, these features are used for training classification. Machine learning is a commonly used recognition and detection technology in the evaluation of table tennis teaching and training and the recognition of sports state, for example, random forest, support vector machine, logistic regression, and neural network. In this paper, SVM is used as the training and testing algorithm. The workflow is shown with Figure 3.

When using the motion data collected by wearable sensors to train and test support vector machine, the classifier learns the training state of athletes from the training set, including physical signals, physiological signals, and acceleration. Accordingly, linear, sigmoid, and RBF are selected as the kernel functions of the classifier. Then, the test set is used to test the accuracy of the classifier in the evaluation of athletes' sports status.

When training SVM classifier, SVM establishes hyperplane to segment samples of different categories. When the distance between samples and two sides of the plane is larger, the model has stronger tolerance to sample noise [26, 27]. The definition of discrimination model is shown in formula (2).

$$f(x) = \text{sign}\left(w^T x + b\right). \quad (2)$$

At this time, the maximum interval and constraints are expressed as

$$\max \ \text{margin}(w, b)$$
$$s.t. \begin{cases} w^T x + b > 0, & y_i = +1, \\ w^T x + b < 0, & y_i = -1. \end{cases} \Rightarrow y_i\left(w^T x + b\right) > 0, i = 1, 2 \cdots N, \quad (3)$$

When solving the optimization problem of the SVM model, the steps are as follows:

(1) Taking hinge loss as the loss function, the Lagrange function is constructed and transformed into $\max_{\lambda,u} \min_{w,b,\xi}(w, b, \lambda, \xi, u)$ by using the strong duality property for easy solution

(2) Calculate the partial derivative of parameter w, b, ξ_i to obtain the optimization function $\min_{w,b,\xi}(w, b, \lambda, \xi, u)$

(3) From step 2, we can get the relation of w, get ss by iterative calculation$\lambda_i > 0$, find the optimal plane by SVs, and complete the solution of the optimization problem

As shown in Figure 4, in the 120 times of training, 98 right hand movements and 75 left hand movements were recognized, and the average heart rate was 96. The movements of the left and right hands include rubbing, attacking, and pushing. When linear, sigmoid ,and RBF are used as the kernel functions of the classifier, the accuracy of action recognition can reach 0.86, 0.79, and 0.82, respectively.

4. Conclusion

This paper makes a preliminary comb of the development process and types of intelligent sensors and states the application research of sensors in the sports industry, especially in table tennis. It further explains in detail how to use wearable sensors to collect the data signals of table tennis training, process the characteristics of the data signals, and recognize and evaluate the motion state with the help of classifiers. Although the recognition method of wearable sensors has achieved high accuracy in some action recognition tasks, there are still many problems to be solved, such as the number and location of sensors, the imbalance of small-scale sample, and the generalization of recognition algorithm. This is also the research direction to be carried out in the future.

Data Availability

The dataset used in this paper are available from the corresponding author upon request.

Conflicts of Interest

The author declares no conflicts of interest regarding this work.

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