

Retraction

Retracted: Intelligent Detection and Analysis of Wearable Devices in Wushu Training

Security and Communication Networks

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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] Y. Yi and T. Yu, "Intelligent Detection and Analysis of Wearable Devices in Wushu Training," *Security and Communication Networks*, vol. 2022, Article ID 1413905, 6 pages, 2022.

Research Article

Intelligent Detection and Analysis of Wearable Devices in Wushu Training

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With the integration and development of artificial intelligence and medical technology, wearable intelligent technology has become an important health testing equipment in people's lives, constantly testing physical function and health. However, according to the movement standards, body indicators, and constantly changing detection indexes of athletes in the exercise process, it can effectively guide athletes to use them correctly and efficiently, which has become an important task of wearable intelligent technology. In the design mode of wearable smart devices, wearable bracelets are designed with acceleration sensors, martial arts training data are measured, and machine learning technology is used to analyze and evaluate the data. When a user uses the method, a sensor is used for collecting the data, the data are transmitted to a processing platform through low-power Bluetooth, the data are analyzed through a program, the accuracy of each action is output, and finally, a standard measurement result of a section of the boxing method is combined. This paper collects and analyzes the data of body characteristics and movement characteristics of wearable intelligent devices in Wushu training. Sensor technology and filtering technology are used to collect and filter the collected information, and better analysis data are obtained. Finally, the filtered data of Wushu are analyzed, and then, the efficiency and performance of different algorithms in Wushu training are compared. Wearable intelligent equipment collects Wushu action training data and then uses fixed threshold classification to recognize Wushu action. The results show that the method used has high accuracy.

1. Introduction

With the continuous development of the information technology industry, its manifestations in the real world are constantly changing [1]. In recent years, wearable smart devices that attract international attention are among one of them. The user can transfer the physical state of the body to the computer processing system through wearable intelligent devices and visually output it in combination with the current physical environment information of the user [2]. At present, this technology is widely used in daily life fields such as medical and healthcare, industry, and sports. Wearable technology is providing convenience for more and more industries through its advantages.

Accurate acquisition of action information is the key to measuring the effectiveness of the detection system. From

the current research results, there are three ways to obtain action information. The first is based on computer vision technology, and through this, it can obtain the athlete's skill characteristics by decomposing the video according to the action and by analyzing the action according to certain standards, generally used in international competitions and large-scale competitions but not in daily training [3]. The second is based on a tracking technology, using a three-dimensional tracking technology to obtain position information, and then analyze the motion state [4]. This method makes it easy to receive interference information from the outside world but its acquisition methods are limited. The third is based on inertial sensor technology; this technology obtains motion data from different parts by wearing inertial sensors and obtains training data by analyzing the obtained data [5].

The detection system based on wearable intelligent equipment can be carried around to reasonably analyze the body load through the physical condition of athletes and contact with the upper and lower conditions; it can make targeted suggestions to athletes according to the predesigned martial arts action state, which is the mainstream martial arts detection system at present [6]. This paper briefly discusses the acquisition of athletes' data and data processing [7]. Literature [8] develops a sensor which is applied to the data acquisition scene of the Wushu boxing ring. The pressure sensor on the body protector is used to test the phase data so that the referee can score. The advantage is that it can improve the accuracy of related tests and competition scoring. It can communicate with other devices in fusion, which can further improve the accuracy of motion data. Literature [9] has strong subjectivity in view of the artificial evaluation method, which is not easy to popularize. Combining wearable computing technology with traditional Wushu training, a wearable Wushu action quantitative evaluation system is designed and developed, which takes the wrist guard as the hardware carrier and combines it with the machine learning method. Through the analysis of sports data, the error analysis model of martial arts movements is established, and then, the neural network quantitative evaluation model of martial arts movements is established. The neural network is trained by an expert scoring strategy to realize the quantitative evaluation of martial arts training.

2. Research on Wushu Training

In the process of daily martial arts training, athletes often harm their bodies because of irregular training movements or unreasonable training intensity. However, these conditions are generally not noticed by athletes or coaches at the beginning, knowing that years of training will eventually lead to long-term injuries. Therefore, it has become a trend to reduce training injuries through real-time monitoring of athletes in the daily martial arts training process.

2.1. Injury Studies. In the daily training of Wushu, because of the competitive nature of the sport itself, injuries of athletes in daily training are inevitable, and because of the rapid development of sports at present, all industries are advancing in a stronger and faster direction, so most athletes face high-intensity and high-load training, which will greatly stimulate their physical potential and improve their training effect if they are within the bearing range of athletes. However, if the injury caused by improper training to athletes is ignored, it might lead to serious lifelong disorders [10]. Through research studies, it is found that quite a number of martial arts athletes have serious knee joint injuries, among which the average incidence of male athletes is 93.0%, and the average incidence of female sports injuries is 85.4%. We must pay attention to such a high incidence of injuries.

2.2. Training Promotion. In the process of martial arts training, mastering the appropriate rhythm and the standard of movements are two major ways to improve the training

effect. In general martial arts training, some athletes excessively pursue difficult training and ignore the rhythm of martial arts movements. Grasping the appropriate routine rhythm can enlarge the advantages of martial arts athletes themselves, and saving their own physical strength can also bring strong visual impact and inner shock to the audience [11]. Second, the most important point in the process of Wushu training is the standard of movements. Wushu has a long history in China, and every Wushu action has been studied repeatedly by predecessors. Through formal Wushu training, sports injuries can be effectively avoided and athletes' levels can be improved in a limited time.

3. Motion Detection and Recognition

3.1. Acceleration Characteristics of Human Motion. Movement is a complex process, and the completion of an action needs to mobilize various parts of the body, and the acceleration of each part is different. The acceleration of the same action will also be affected by different time and place environments. According to the research of Bhattacatyta et al. and Cappozzo, we find that the acceleration presents a certain range law under different motion states, as shown in Table 1. According to the research of Carlijn et al. [12], in the daily movement of the human body, the frequency of acceleration component in the vertical direction is higher than that in the horizontal direction in most cases, which can also be seen from Table 1.

3.2. Data Processing Based on Acceleration Sensor. The general process of human motion recognition can be divided into the following modules, as shown in Figure 1. In the recognition process, the acceleration data generated by different motion parts of users are first collected. The second is data preprocessing, which mainly deals with data errors to reduce the influence of error values on data. Third, according to a certain feature extraction algorithm, the processed data are extracted to meet a certain standard feature vector. Fourth, feature vectors are selected, and the related characteristics of user motion patterns are represented by these vectors. These vectors will be used to identify classifications and compare templates [13, 14].

Usually, there is a training module in template training, in which the reference model for recognition is trained. The data used for comparison in the reference model is usually the feature vector that has passed the data selection. These vectors are stored in the memory, and after a certain training algorithm, the characteristics of this template are enlarged to become a certain standard, thus becoming a reference model in this module [15].

By matching the feature vector of the input sample and the feature vector of the saved reference model, the similarity between the sample data and the template data is obtained, and the result is output.

3.2.1. Data Acquisition Module. As the basic module of the system, the data acquisition module plays an important role in the whole system, and almost all the subsequent

TABLE 1: Table of motion parameters.

Motion state	Ankle	Back	Head
Running	3.0~12.0 g	0.9~5.0 g	0.8~4.0 g
Walk	-0.3~0.8 g	-0.3~0.4 g	-0.2 g~0.2 g

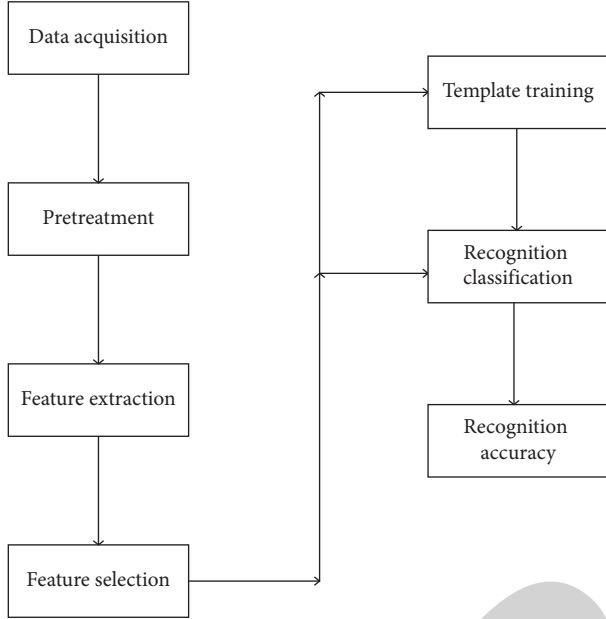


FIGURE 1: Human motion recognition process module.

calculations need to use the original data directly or indirectly. When designing the data acquisition device, we need to consider the particularity of users. The monitoring system is aimed at athletes who carry out martial arts training daily. If the wired transmission is used when choosing the data transmission mode, the comfort of the system will be greatly reduced and the completion of training actions will be affected. Therefore, it is suggested to use wireless data transmission and then process and calculate the data through external devices.

3.2.2. Pretreatment Module. Window processing: In the process of motion acceleration, signals are generally presented in the form of a data stream. When the data are too long, the results obtained by calculating this data stream are mostly meaningless. Therefore, we recognize the motion state by adding windows, as shown in Figure 2. The setting of window length is determined by specific action time, and there is a 50% overlap between each sliding window. In order to reduce the window effect on the data processing results when adopting windowing processing, that is, the action delay caused by a too large window and the incomplete action caused by too small window selection, we should carefully handle the window selection principle. It is shown in Figure 3.

As can be seen in Figure 3, the sliding window is an acquisition cycle for the corresponding signal, and the length

of the window is 500. Only by continuously acquiring the information, can the data be effectively obtained, thereby improving the recognition efficiency of the algorithm.

Filter function: When measuring the actual acceleration data, due to the complexity of martial arts movements and the high sensitivity of sensors, the data results will inevitably be influenced by themselves and the outside world, including hardware circuit, transmission noise, disturbance frequency noise, and athletes' unconscious jitter. The acceleration of the output result generally consists of two parts, as shown in the following equation:

$$a_m = a_r + a_e, \quad (1)$$

where a_m is the actual measured value, a_r is the real acceleration from athletes, and a_e is the error acceleration from variable influences.

In order to reduce the errors from various aspects, the Kalman filter is selected for processing. This filter can process noisy input and observation signals in linear state space to obtain real data signals, and the processed data are obviously smoother, more stable, and more accurate. At present, this filtering method has been widely used in various fields of aviation, aerospace, and national economy and has become one of the most basic tools for processing and controlling signals; the motion data after the Kalman filter equation are obviously smoother and more continuous.

We build a mathematical model by Kalman filter, assuming that the system data, that is, the acceleration change trend, can be expressed by X_t , and we assume that the data of the system is the state in discrete time, and the state of the system is affected by the input data, and it is disturbed by the noise from the outside world in this process. Under the above assumption, we define the state of the system at k time as x_t (-stands for a priori and $\hat{}$ stands for estimation) and derive the Kalman filter equation (1).

The state value \hat{x}_t of the system at time k is predicted by the optimal state value \hat{x}_{t-1} at time $k-1$ and U_{t-1} is the system input value at time $k-1$.

$$\hat{x}_k^- = A\hat{x}_{k-1} + BU_{k-1}. \quad (2)$$

We predict the new error P_k^- from the last error covariance P_{k-1} and process the noise Q :

$$P_k^- = AP_{k-1}A^T + Q. \quad (3)$$

We then calculate the Kalman gain as

$$K_k = P_k^- H^T (HP_k^- H^T + R)^{-1}. \quad (4)$$

Here, K_k represents the Kalman gain matrix, which mainly controls the weight of the observed quantity to the update of the estimated error state quantity. The rows of this matrix represent the state and the columns and represent the observed value. R represents the actual observation noise error covariance matrix, and there are interference factors in the information gain.

Then, a corrective update was carried out

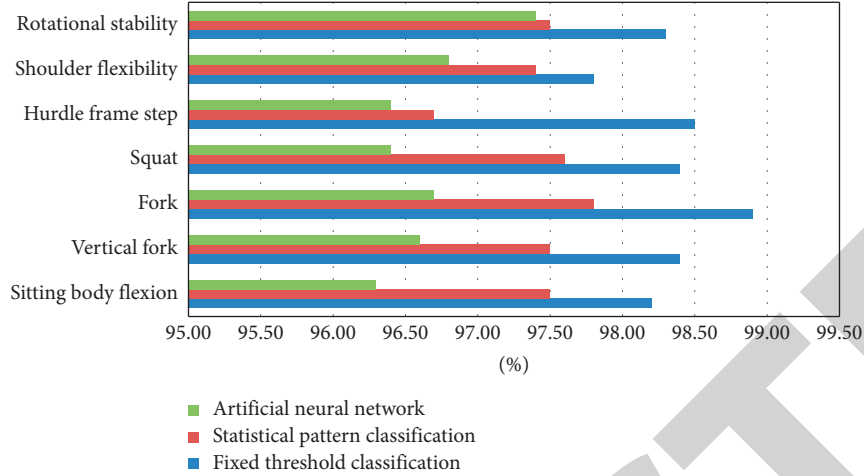


FIGURE 2: Comparison chart of classification algorithms.

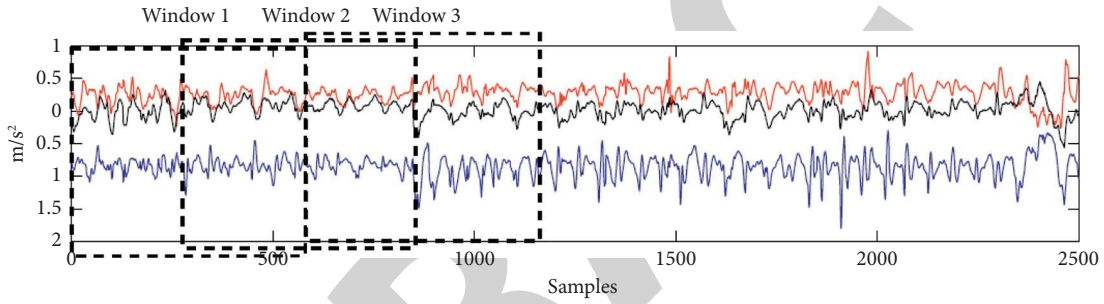


FIGURE 3: Windowing processing process.

$$\hat{x}_k = \hat{x}_{k-1} + K_k (y_k - H\hat{x}_{k-1}). \quad (5)$$

We then update P_k for the next iteration of estimating $K+1$ time.

$$P_k = (I - K_k H) P_{k-1}. \quad (6)$$

The parameters in the formula are explained as follows: A : $n \times n$ is the state transformation matrix on x_{k-1} ; B is an $N \times 1$ input control matrix on the input data U_{k-1} ; H is the $m \times n$ observation model matrix; I is the unity matrix of order $n \times n$; K_k is the $M \times N$ order matrix, representing the Kalman gain; and P_k is the $n \times n$ order prior error matrix.

3.2.3. Feature Extraction. The accurate judgment of action data in a wearable intelligent device system depends on the key characteristics of the recognized object and the accurate identification and grasp of the data. By selectively extracting the data in the memory, the numerical value that can fundamentally affect the result data is obtained, which plays a vital role in the whole system.

According to the statistics of feature extraction methods in wearable devices in recent years, the methods of extracting acceleration signals can be roughly divided into three categories: time domain analysis, frequency domain analysis, and time-frequency analysis. In this paper, based on the

selection of time domain analysis methods that can be directly extracted from the acceleration signal, a simple method is selected in which the amount of calculation is moderate; so this method is selected for data extraction.

By using a three-axis acceleration sensor to obtain three-dimensional acceleration information, that is, X -axis, Y -axis, and Z -axis, and the acceleration reflects the vectors of different movements of Wushu athletes. In order to make the calculation simple, we introduce the amplitude change value of acceleration signal a_{SVM} to describe the acceleration of athletes' movements. Let us assume that the values of t , a_{SVM} , at any time are expressed by the following formula, where a_{xt} is the acceleration on the X axis, a_{yt} is the acceleration on the Y axis, and a_{zt} is the acceleration on the Z axis:

$$a_{SVM} = \sqrt{a_{xt}^2 + a_{yt}^2 + a_{zt}^2}. \quad (7)$$

However, due to the complexity and changing characteristics of martial arts athletes' movements, it is impossible to accurately judge their movement state only by using acceleration $\delta_{a_{SVM}}$, so we once again introduce the change of acceleration, that is, variable acceleration $\delta_{a_{SVM}}$, to describe the changes of athletes' movements. Variable acceleration can represent the speed described by visual icons. When using waveform icons to describe the changing trend of athletes' movements, $\delta_{a_{SVM}}$ is the difference between adjacent peaks and troughs of $\delta_{a_{SVM}}$. We judge that when the

TABLE 2: Wushu training contents.

Time	Content
10 minutes	Physical function training action preparation
20 minutes	Leg method: positive kick (8×2), side kick (8×2), bounce kick (8×2), and oblique foot pat (8×2)
20 minutes	Horse step changes to lunge punch, leg punch, kick and push palm, servant step piercing palm, and action combination
20 minutes	Twenty-four, a kind of traditional Chinese shadowboxing (tai chi chuan) and three short sticks.
10 minutes	Pattern relaxation run

TABLE 3: Basic information of test objects.

Characteristics	Subject	<i>t</i>	<i>P</i>
Height	178.25 ± 3.25	0.214	0.473
Weight	71.50 ± 4.874	0.365	0.632
Age	21.50 ± 2.31	0.475	0.521

TABLE 4: Physical fitness test index.

Action	Subject	<i>t</i>	<i>P</i>
Sitting body flexion (CM)	12.275 ± 3.25	1.245	0.124
Vertical fork (CM)	27.36 ± 4.124	-0.235	0.523
Fork (CM)	32.25 ± 5.321	0.135	0.124
1-minute sit-ups (times)	38.74 ± 5.325	0.245	0.214
Crane test (s)	12.125 ± 6.45	0.574	0.478

amplitude of acceleration change is less than 0.2 g and lasts for more than 5 s, we think that the athlete is in a static state.

3.2.4. Feature Selection. Due to the complexity of recognition action, the number of feature vectors extracted from data is large and the spatial dimension is high. How to select the data with association relationship from the extracted data and reduce data redundancy is also a link that cannot be ignored. Therefore, we often select after extracting relevant feature information and exclude those disturbing and irrelevant data. Common feature selection methods include principal component analysis (PCA), linear decision analysis (LDA), and so on.

Linear decision analysis is an improvement of principal component analysis, which has the best discrimination in the sense of minimum mean square error. Based on this analysis, we can reduce the data dimension, thus simplifying the algorithm and saving memory space.

4. Recognition of Wushu Action Training Efficiency

4.1. Data Analysis of Wushu Action Training. Modern functional training concept holds that balance ability, flexibility, sensitivity, and coordination constitute the foundation of physical fitness and are the foundation of strength, speed, and endurance. Among them, physical fitness is concentrated in the maneuverability required by sports, and maneuverability is a purposeful action based on stable body posture, which reflects the dynamic

control of athletes' body stability and maneuverability, respectively.

The premise of normal special technical teaching and training of Wushu training content, physical function training action preparation exercises, and the content arrangement is given in detail in Table 2. The basic situation of the subjects is shown in Table 3, and the physical fitness test indexes are shown in Table 4.

As can be seen from Table 4, the average scores of the experimental group's sitting body flexion, vertical fork, horizontal fork, one-minute sit-up, and stand-out test are 12.275 cm, 27.36 cm, 32.25 cm, 38.74 times, and 12.125 seconds.

4.2. Comparison of Wushu Action Training Recognition. According to the characteristics of the system audience and motion features, motion recognition algorithms have their own emphasis. Common classification algorithms include fixed threshold classification, statistical pattern classification, and artificial neural network classification algorithms. The fixed threshold algorithm is simple, efficient, and easy to operate by dividing the data and judging the input data directly. At present, most monitoring systems about falls use this algorithm for action classification. Statistical pattern classification takes the sample data stored in the system as the standard and divides the research objects into their own fields before analyzing the data. Common statistical methods include the C4.5 decision tree, hidden Markov model, K nearest neighbor algorithm, and so on. From the perspective of martial arts training, the recognition and classification algorithm meets our requirements. An artificial neural network

TABLE 5: Accuracy of motion model recognition.

Model	Sitting body flexion (%)	Vertical fork (%)	Fork (%)	Squat (%)	Hurdle frame step (%)	Shoulder flexibility (%)	Rotational stability (%)
Fixed threshold classification	98.2	98.4	98.9	98.4	98.5	97.8	98.3
Statistical pattern classification	97.5	97.5	97.8	97.6	96.7	97.4	97.5
Artificial neural network	96.3	96.6	96.7	96.4	96.4	96.8	97.4

can realize complex nonlinear mapping by simulating the network structure composed of neurons in the human brain and has high fault tolerance while completing the classification task. However, due to the complex structure of this classifier, it is not used in this paper. It is shown in Table 5 and Figure 2. In the process of experimental simulation, three algorithms, threshold classification, statistical pattern recognition, and artificial neural network, are used to recognize and apply the corresponding actions of Wushu. In this paper, the threshold classification method is used to classify the martial arts data collected by wearable technology. When other algorithms classify the data, the recognition results are not good.

For the accuracy of various algorithms as shown in Figure 2, the recognition effect of fixed threshold classification is better: the lowest in shoulder flexibility recognition is 97.8% and the highest in fork is 98.9%. Overall, the other two methods have the best recognition accuracy and better application effect.

5. Conclusion

By effectively combining wearable intelligent devices with martial arts training, through intelligent data research and processing, the standardization degree of athletes' current movements is effectively analyzed, as well as, by determining the direction of promotion and improvement, it can help athletes avoid overwork injury and overload training injury in daily Wushu training to a great extent and improve the standardization of athletes' movements by comparing them with standard training templates. The correlation between sliding window size and motion recognition rate is analyzed, and the appropriate window is selected. The use of threshold classification is to observe whether to use a better classification algorithm for the identification or combined with other intelligent algorithms for use. Therefore, the system uses better sensors to collect running data and collects it in combination with different motion scenes.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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