

Retraction

Retracted: Wearable Product Design for Intelligent Monitoring of Basketball Training Posture Based on Image Processing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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) Peer-review manipulation

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.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

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] L. Zhang, Y. Sun, M. Wang, and Y. Pu, "Wearable Product Design for Intelligent Monitoring of Basketball Training Posture Based on Image Processing," *Journal of Sensors*, vol. 2021, Article ID 8964433, 15 pages, 2021.

Research Article

Wearable Product Design for Intelligent Monitoring of Basketball Training Posture Based on Image Processing

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The algorithms of wearable image processing technology equipment have certain versatility and can be widely used in popular fields such as medical treatment, factories, drone development, human-computer interaction, virtual reality, and physical education. In order to deeply study the monitoring effect of smart wearable products based on the image processing technology on basketball training postures, this article uses the product manual comparison method, data collection method, and equipment development method to collect samples and analyze and develop intelligent monitoring equipment, streamlined algorithm. And it integrated and developed a wearable product that can monitor athletes' training posture in real time during basketball training. After the product was researched, the training program of the product was used for low-handed dribbling. The first training lasted for 3 minutes and 10 seconds, and the second training lasted for 2 minutes and 45 seconds. The prototype and manual dribbles were studied in these two cases. The results showed that the prototype reminded the participants 31 times, while the coach only reminded them 13 times due to the large number of people. By comparing the satisfaction scores of the fitness software and the products developed in this article, the score ranges from 1 to 5 points, which is very consistent with the score of 5, and it is very inconsistent with the score of 1. Through the trial of this scene, positive information was obtained. The evaluation of the prototype is generally above that of the fitness software. The number of people eager to use the prototype again is 10 times more than that of the fitness software. These data are from the first combination chart and the third combination chart. The corresponding explanations and experimental methods will be introduced in the description of these two combination charts later. The prototype can widely cater to the public's sport preferences. It is basically realized that starting from the image processing technology, a smart monitoring wearable product with high evaluation and good effect has been designed.

1. Introduction

With the increasing enrichment of material life, the state has invested more effort to promote the improvement of students' comprehensive quality, so as to promote the comprehensive development of students' morality, intelligence, and physical fitness. However, due to the impact of exam-oriented education, there is a shortage of physical education teachers in basic schools, which has led to the fact that the

quality of physical education in primary schools is relatively low. If the teacher-student ratio is too low, the coach or physical education teacher will not be able to fully guide or take care of each student. If the bad posture in training is not corrected for a long time, it will develop into a bad habit. It will be difficult to change in the future. The essence of smart wearable products is to provide users with information, present it to users in the form of data, and play a role in the form of wear, so as to achieve the ability to enhance

human perception. However, the current user acceptance of wearable products is not high and the use process is relatively cumbersome.

Therefore, it is very necessary to research and develop a new high-level intelligent monitoring platform using the latest science and technology combined with the image processing technology, system recognition mode, detection and analysis technology, and transmission technology. This can not only realize the visualized and intelligent identification and monitoring of the basketball training status, improve the effectiveness, safety, and stability of basketball training for students, but also realize remote unified monitoring, processing, storage, and module control management, allowing all intelligent monitoring systems to complete mutual integration to meet the structured and integrated management of the image monitoring system. As users further understand smart wearable products and the development of image processing technologies, smart monitoring wearable devices will become an indispensable part of people's lives in the future.

In fact, foreign countries pay more attention to basketball and basketball training arrangements are more reasonable. Many scholars have done design research on this kind of intelligent monitoring equipment for image processing. In 2017, the purpose of CHO research is to develop sport monitoring intelligent clothing based on textile sensors to promote sport effects. The preliminary experiment is to repeatedly bend and extend the arms and legs within the range of motion, supplemented by the modified experimental results. The results show that children's clothing can effectively perceive children's movement through the fabric embedded with the textile sensor developed in this study. However, there are errors in the research results [1]. In 2018, Brown et al. were to assess the acute changes in the ground reaction experienced by the baby stroller system when walking on the ground. Paired sample *t*-test and image processing analysis were used to evaluate the difference between loading and unloading conditions. Results of the additional load increased all the parameters of ground reaction force. However, the magnitude of the force change is affected by the carrier structure. However, this research process is not rigorous [2]. In 2019, Salobir et al. proposed the 3D printing technology, which makes it possible for small-scale production of tens to hundreds of pieces. Through systematic research and considering the principle of small-scale production, the cost of products can be reduced. They created a computer program to let users know the appropriate 3D printing technology. In order to simplify the use, the program is also integrated into the product development process. However, the procedure only involves product production without technical description [3]. In 2017, the purpose of Jang et al.'s study was to determine the impact of differences in 8-week training programs conducted by basketball club members on their body composition, basic physical fitness, and anaerobic capacity. It was found that there was no significant effect on body composition. In terms of basic physical fitness, muscle strength, flexibility, speed, agility, and balance have been significantly improved. Although the data is accurate, the measurement path has no

sense of science and technology [4]. In 2016, Schelling and Torres-Ronda proposed a strength and neuromuscular strength training method to help basketball players achieve excellence in sport-specific skills and decision-making. It integrates the latest scientific knowledge of strength training and puts forward a practical, comprehensive, and specific cover basketball movement. However, the image processing technology is not used to study basketball training [5]. In 2017, Dehghansai et al. provided a detailed training history for 52 male and female athletes that trained at the Canadian Wheelchair Basketball National College. Athletes show a similar development pattern in their sport career. However, athletes with congenital disabilities began to participate in wheelchair basketball and unorganized training at a significantly younger age. Because there is no technical support, the data expression is ambiguous [6]. In 2017, the purpose of Armstrong et al.'s research was at comprehensively reviewing some potential smart materials and their application fields in gerontology. Therefore, a brief introduction is given to the various functional smart materials currently available and their possible applications in aging-related problems. In conclusion, some of the most important applications of geriatrics may be collecting health-related feedback or information and providing personalized care in a variety of sensor scenarios. The research purpose has been achieved, but the practicability is not high [7].

The innovations of this article are as follows: (1) This paper introduces the preprocessing method of the image at the beginning and realizes the graying, denoising, and equalization of the image. (2) In this study, the general operation technology is used to deeply study the specific basketball dribbling posture, and the research results can complete the functions that can not be realized by special intelligent wearable products. (3) In the algorithm research, an algorithm for monitoring the temporal movement rate of the environment is provided. In this study, the algorithm can effectively monitor the basketball dribbling speed. Through the above work, it is basically ensured that the intelligent wearable products designed in this paper have good efficiency and accuracy in image processing of basketball training posture.

2. Implementation Method of Wearable Products for Intelligent Monitoring of Basketball Training Posture Based on Image Processing

2.1. Introduction to Basketball Training Posture. Basketball is a comprehensive sport of running, jumping, and throwing. Many sports are completed under the condition of physical instability, especially rebounding, jumping, and shooting. All these require athletes to complete their actions under the condition of maintaining physical balance and joint strength training through appropriate core strength training, which is combined with traditional strength training. On the basis of strengthening the muscle strength of the whole body, we can strengthen the strength of the core area and make the body more stable and have a stronger ability to

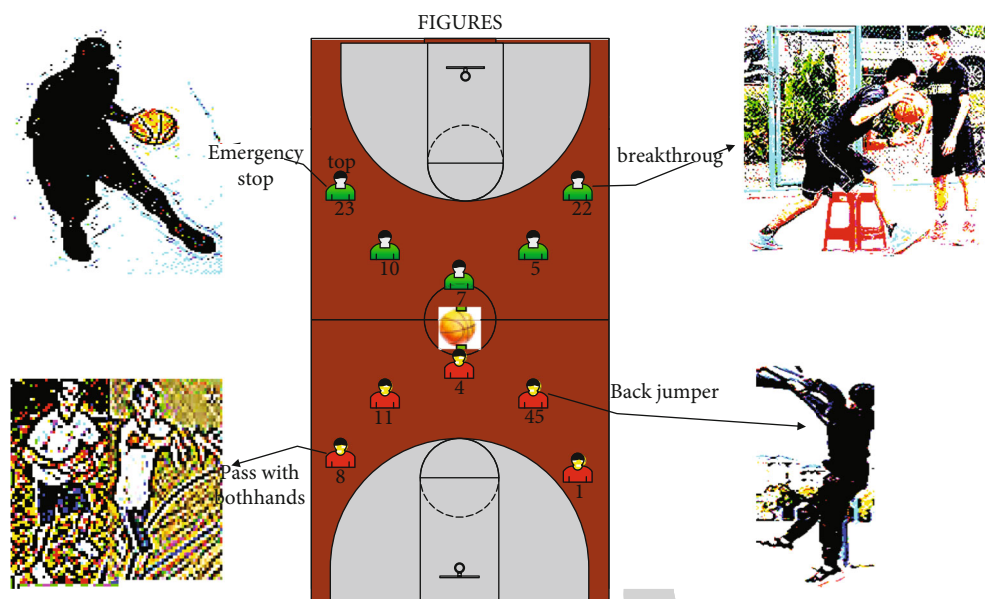


FIGURE 1: Basketball technical action pictures.

maintain balance, so that we can complete the action and do the best [8]. See Figure 1 for specific technical actions.

It can be seen in Figure 1 that some specific pictures of basketball technical actions are introduced and a brief text description of these four technical actions is given below [9].

2.1.1. Emergency Start and Stop Technology. EMERGENCY START and EMERGENCY STOP define the general term of various starting and emergency steps used by athletes in order to select and seize a favorable position and gain time and space. The mobile technology includes many actions; the focus is on running and stopping while moving.

2.1.2. Two-Handed Pass Technique. Receiving the ball is a way to stop the ball from running in the air. Passing is a method of purposefully transferring the ball between offensive players. Whether it is two-handed or single-handed catching, corresponding resistance must be applied to the ball in the opposite direction of the ball's flight, so that the speed of the ball is reduced to zero.

2.1.3. Breakthrough Technology. There are two breakthrough techniques: one is the breakthrough with the ball and the other is the breakthrough with the dribble. The ball holding breakthrough technology is composed of four ring segments: kicking, turning, shoulder probing, pushing and releasing the ball, and acceleration. When using the breakthrough, the four ring segments should be closely linked, the action should be consistent, the speed should be fast, and they can change the direction, change the speed, make an emergency stop, turn, pass, and shoot at any time [10].

2.1.4. Reclining Jumper Technique. Jump shooting mainly refers to jumping one-handed shooting, which is one of the scoring methods commonly used by basketball players in the world. Athletes can use it in different distances, different directions, and different angles, such as high jump shots, fast jump shots, and turn away from the opponent.

2.2. Intelligent Monitoring System and Related Technologies.

Wearable human body training transition monitoring equipment involves the integration of ergonomics, posture capture, data analysis and processing, and other fields of knowledge. It is a more complex wearable system design [11].

2.2.1. General Anthropometric Knowledge. The measurement of the basic information of the human body mainly involves the conventional static constants such as the measured human body geometry, the degree of freedom, and the angle of motion, under certain conditions.

Refer to Figure 2 for the basic motion forms of the human body. In the long process of evolution, humans have gradually realized the division and collaboration of upper and lower limb activities. Combining the flexible movements of the trunk, wrist, and fingers, the forms and ways of human motion can be varied.

It can be seen in Figure 2 that the basic motion and action forms are summarized as pushing, pulling, whipping, buffering, pushing, swinging, twisting, opposite motion, etc. At the same time, the upper limbs, lower limbs, and the whole body are divided and compared [12]. The human body's junctions, bones, connectors, and muscle groups build up a complex human body's movement system. The bones are connected by the stretching action of the junctures. At the same time, the skeletal muscles and muscle groups above the bones and the realization of the movement process also depend on the stretching and contraction of the muscles [13].

2.2.2. System Architecture. The system consists of three modules, and the specific system architecture is shown in Figure 3.

It can be seen in Figure 3 that, first, the image is collected by the front module of the monitoring system installed on the basketball training hall. This module is constructed from

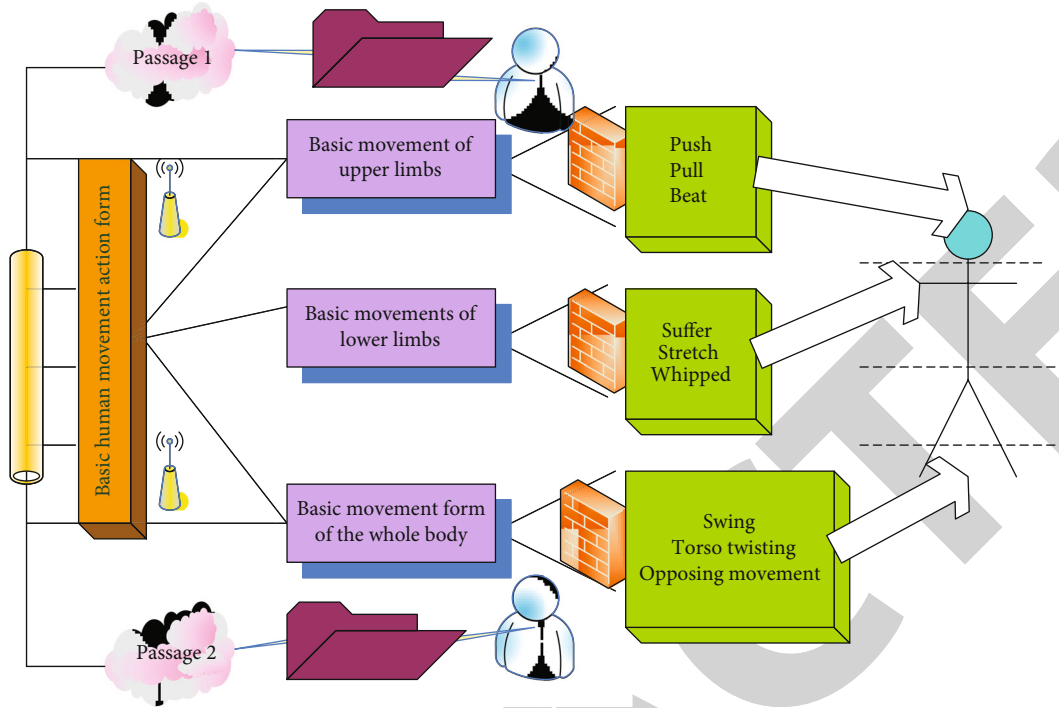


FIGURE 2: The basic motion form of the human body.

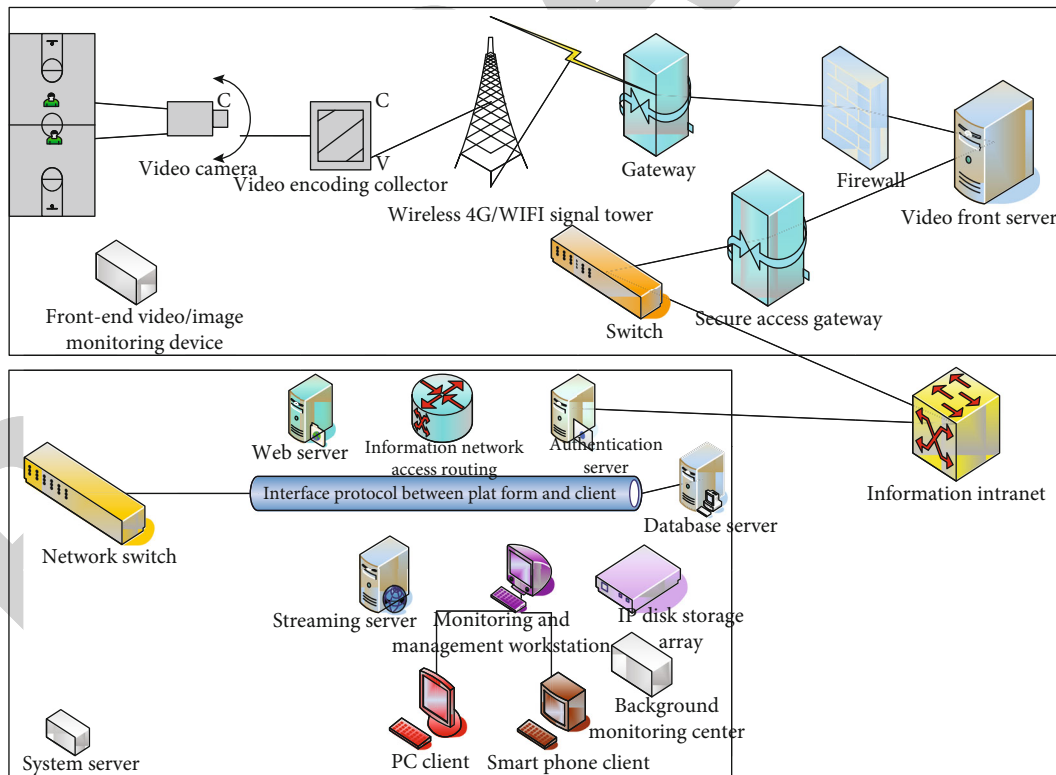


FIGURE 3: System architecture diagram of the intelligent monitoring platform.

the shooting system or server and external equipment, 4G transmission module, code machine, capacity battery, and sound equipment [14]. Secondly, through the 4G module, network information transmission technology, and video

front-end node, the remote two-way transmission and control of information such as encoding, packet communication, audio and video data, and warnings are realized. Finally, the packaged video stream is connected to the

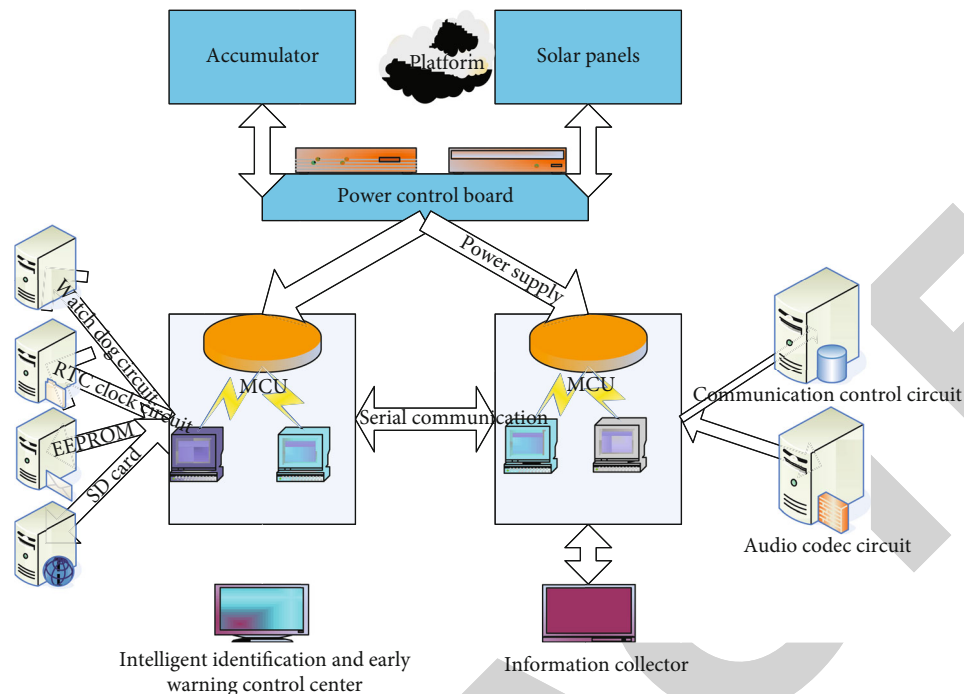


FIGURE 4: Front-end video/image monitoring device design framework.

streaming media node through the private network for video decoding, and then, the image is obtained from the decoded video stream and the algorithm database node is used for intelligent detection and recognition [15].

2.2.3. Image Monitoring Device. The hardware part of this platform includes the image processing node, storage module, system transmission node, control node, and audio warning module. These modules are mainly composed of a controller, a circuit, a transmission circuit, a transmission module, a wired super network interface, a power supply, and a storage unit. As shown in Figure 4, the framework is designed for the image monitoring device.

It can be seen in Figure 4 that the image module collects the signal source at the scene, uses a digital technology decoder to convert it into a digital image signal, and then connects to the DSP device to calculate and process the image at any time. The M device completes the solution of data transmission, storage of information, and Cloud computing platform control [16]. In the real-time data transmission through the wireless transmission module and the background core components, the interface data of the image conversion is converted into a database for wireless transmission [17].

2.3. Introduction to the Image Processing Technology and Algorithms. The image processing technology is a technology that uses a computer to process image information. It mainly includes image digitization, image enhancement and restoration, image data coding, image segmentation, and image recognition. An image is a combination of pixels and colors. It is obtained by video cameras, scanners, digital

cameras, and other equipment, or it can be generated by a drawing software. The picture represented by the image is delicate and rich in layers and colors. Each pixel of the image is stored in the computer point by point, which occupies a large storage space. According to the understanding of the various modules of the system, the image processing node is the core and key of the whole system. The focus of this module is the two parts of image preprocessing and image analysis. Among them, image preprocessing is the premise of this module and image analysis is relatively complicated, involving more content and a certain degree of difficulty. The purpose of image enhancement is to improve the visual effect of the image. It is a collection of various technologies and has not yet formed a set of general theories. Commonly used image enhancement techniques include contrast processing, histogram correction, noise processing, edge enhancement, transformation processing, and false color. In multimedia applications, image enhancement processing is mainly performed on various images and various image processing software generally supports the image enhancement technology. The algorithm research and verification of image preprocessing and image analysis will be introduced in detail below. The flowchart of the image processing module can be seen in Figure 5 [18].

From the flow of the image processing module in Figure 5, we can use the powerful image processing capabilities of MATLAB and the simple language close to scratch paper to design and verify the algorithms of the image processing modules involved in the whole process [19]. Images are the main source of information obtained and exchanged by human beings. Therefore, the application field of image processing must involve all aspects of human life and work,

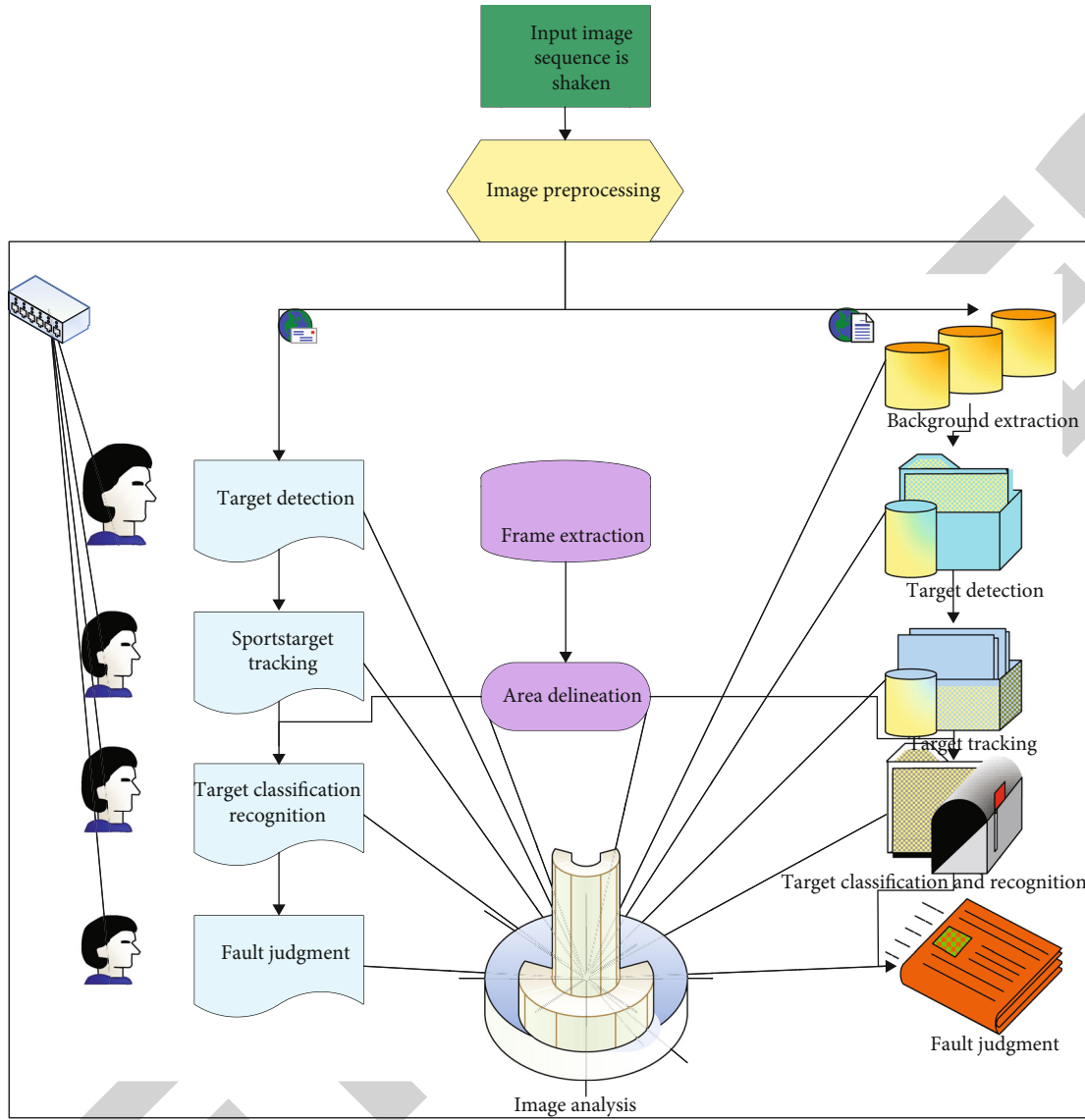


FIGURE 5: Flow chart of the image processing module.

including the aerospace and aviation technology, biomedical engineering, communications engineering, industry, engineering, military and public security, culture, and art.

2.3.1. Image Preprocessing. Image preprocessing is a basic and important part of the processing structure. Data preprocessing refers to some processing of data before the main processing. For example, before the conversion or enhancement of most of the geophysical area observation data, the irregularly distributed survey network is first converted into a regular network through interpolation, so as to facilitate the calculation of the computer. Usually in real life, the initial image obtained by this system is not enough. For example, the image is poor due to noise, light, etc., so what needs to be done is to process the video image in advance. The image preprocessing techniques used here include grayscale transformation, smoothing filtering, and balancing [20].

Since the monitoring software is mainly aimed at the target object, such as the general recognition of athletes, it does not need to be as thin as hair recognition, which is a large-scale and crude recognition, so its aging can greatly reduce the subsequent image data and improve the efficiency of the system [21].

If the image of the black formula is given, the g weight of each pixel can be given by the following equation:

$$g = \begin{cases} \pi, & \text{when } y \leq h, \\ 360 - \pi, & \text{when } y > h. \end{cases} \quad (1)$$

Among them, g is the pixel value, and then, subdividing

$$\pi = \text{through} \left\{ \frac{(1/2)1/2[(e-h) + (e-y)]}{[(e-h)^2 + (e-y)(h-y)]^{1/2}} \right\}, \quad (2)$$

$(e - h)$ represents the saturation parameter and the saturation component is given by

$$t = 1 - \frac{3}{(e + h + y)} [\max(e, h, y)]. \quad (3)$$

Among them, $(e + h + y)$ is the component, and finally, the brightness is given by

$$l = \frac{1}{3}(e + h + y) + x \oplus y + \sum_k \binom{n}{k}. \quad (4)$$

Calculate the value of l with e , h , and y of a pixel, so that the grayscale image can be obtained [22].

Due to the influence of the side and input hardware, the collected images may contain a lot of noise and other defects. Supposing that the multidimensional structure of the signal is $l(a, b)$, then, the noise can be considered as interference to the light, which is represented by $o(a, b)$ [23].

The mean value indicates the overall intensity of the noise in the image:

$$\bar{o} = f[o(a, b)] = \frac{1}{n * o} \sum_{a=1}^n \sum_{b=1}^o o(a, b). \quad (5)$$

\bar{o} is the representative value of intensity. Variance indicates the difference in the strength of the noise distribution in the image:

$$\rho^2 = f\{[o(a, b) - \bar{o}]^2\} = \frac{1}{n * o} \sum_{a=1}^n \sum_{b=1}^o [o(a, b) - \bar{o}]^2. \quad (6)$$

Among them, n , o is the number of rows and columns of the image, respectively.

Due to the complexity of the noise type, its methods are also diverse, which can be divided into linear filtering and nonlinear filtering [24].

At any point (a, b) , the value of the restored image l is the arithmetic mean calculated with the pixels in the area defined by t_{ab} . Namely,

$$l(a, b) = \frac{1}{no} \sum_{(t,s) \in t_{ab}} h(t, s). \quad (7)$$

Among them, $l(a, b)$ is the average value of the algorithm and the nonlinear filter replaces the value of the pixel with the median value of the gray in the pixel neighborhood:

$$l(a, b) = \overset{\text{medium}}{\leftrightarrow} \sum_{(t,s) \in t_{ab}} \{h(t, s)\}. \quad (8)$$

Among them, t_{ab} is a constant option. The median σ of a set of values is such a value that half of the set of values is less than or equal to σ and half is greater than or equal to σ .

In the process of photography or image storage, due to some reasons, such as insufficient illumination or nonlinearity, the image will be relatively weak. The pixel size reclassi-

fication method can be used to improve the image contrast [25].

The specific method is as follows:

$$q(t_g) = \frac{o_g}{o} + f(x) \in \begin{cases} -a, a < 0 \\ a, a \geq 0 \end{cases}, \quad g = 0, 1, \dots, i - 1. \quad (9)$$

Among them, o is the total number in the image [26]. Calculate the accumulation chart of the starting photos, that is,

$$s_g = f g(t_g) = \sum_{u=0}^g \frac{o_1}{o} = \sum_{u=0}^g q_t(t_u) \quad o \leq t_g \leq a, \quad g = 0, 1, \dots, i - 1. \quad (10)$$

Among them, s_g is the growth value and t_g is the mean value, rounding calculation:

$$s_g = uos \left[(o - 1)s_g + \prod_{k=1}^n A_k * \frac{g}{o} \right]. \quad (11)$$

Define the mapping relationship, $t_g \xrightarrow{\Delta} s_g$, and calculate a new histogram [27].

$$q_1(s_g) = \frac{o_g}{o} + \iiint_{i=1}^u s_k \boxtimes g = 0, 1, \dots, q - 1. \quad (12)$$

Among them, $q_1(s_g)$ is the preparation process of the new histogram.

2.3.2. Target Detection. Target monitoring is at the bottom of the entire monitoring software and is the basis for other extensions such as discovery tracking and target detection. Only when the moving target is detected correctly can the following work be carried out; otherwise, it will cause a lot of mistakes and errors to make the following work unable to be carried out.

The interframe difference method is based on the principle that the gray value and position of the background pixels are unchanged to detect the foreground moving target and the difference image is obtained by performing the difference operation on the two images at different moments. In the actual process, it refers to successively reducing the two adjacent target images to form a difference map. In the difference map, if the difference value is greater than the determined closed value, the corresponding pixel is taken as "1," otherwise it is taken as "0." This produces a nonzero area, and the detection object can be detected by using the nonzero area [28].

$$w_{s-1,s}(a, b) = |l_s(a, b) - l_{(s-1)}(a, b)|. \quad (13)$$

Use formula (13) to calculate the difference between adjacent frames to obtain a differential image. Among them,

TABLE 1: Comparison of advantages and disadvantages of various target detection algorithms.

Method	Advantages	Disadvantage	Efficiency (s)	Correct rate
Interframe difference method	Low computational complexity	Insufficient extraction	20.5	99.3%
Background difference method	Good detection effect	Sensitive	16.3	96.5%
Optical flow field method	Can be used for exercise status	Large amount of calculations	25.2	97.8%

$l_s(a, b)$ and $l_{(s-1)}(a, b)$ are two consecutive frames of images and $w_{s-1,s}(a, b)$ is a frame difference image. Then, select the closed value to binary the difference image to obtain the initial target and add it to solve the noise to get better results as needed.

The background difference method creates a model for the moving background. When a target appears, the data of the current image frame will change. By comparing the current image frame with the background model, the area with a large brightness change is determined, which is considered to be the front part. The key of this method is to choose a suitable image as the background and continuously and rapidly update it according to different situations, that is, to increase the adaptability. Its formula is as follows:

$$w(a, b) = \left| l_s(a, b) - y_{(s-1)}(a, b) \right|, \quad (14)$$

where $w(a, b)$ is the difference result, $l_s(a, b)$ is the image at the current moment, and $y_{(s-1)}(a, b)$ is the background image at the previous moment. The calculation speed of this method is very fast, and a complete and accurate description of the moving target area can be obtained.

Motion detection based on the optical flow method uses the optical flow characteristics of moving targets that change over time.

Suppose that the gray value of the point (a, b) on the image at time s is $u(a, b, s)$, and the corresponding point is Δs after the interval $u(a+\Delta a, b+\Delta b, s+\Delta s)$. When $\Delta s \rightarrow 0$, the gray level can be considered unchanged, so there is

$$u(a, b, s) = u(a+\Delta a, b+\Delta b, s+\Delta s). \quad (15)$$

Expanding formula (15) by Taylor and ignoring the second-order infinitesimal, we get

$$u_a v + u_b m + u_s + \tan \tau = \frac{\sin \tau}{\cos \tau} = 0, \quad (16)$$

where $v = wa/ws$ and $m = wb/ws$ are the optical flow components in the a and b directions, respectively.

Let the smoothness constraint term be minimized

$$f_t = \iint [v_a^2 + v_b^2 + m_a^2 + m_b^2] wawb. \quad (17)$$

Among them, f_t belongs to the minimized value and the finally obtained optical flow should satisfy the following formula:

$$\max \left\{ f_t = \iint [v_a^2 + v_b^2 + m_a^2 + m_b^2 + \vartheta(u_a v + u_b m + u_s) 2] wawb \right\}. \quad (18)$$

Among them, $u_a v + u_b m + u_s$ is the average value and the minimization objective function is

$$\max \left\{ f = \sum_u \sum_k (t_{uk} + \vartheta z_{uk}) \right\}. \quad (19)$$

Find the derivative of the above formula with respect to $\overline{v_{gs}}, \overline{m_{gs}}$. And set it to zero, and finally, get the general process:

$$v_{gs}^{o+1} = \overline{v_{gs}^o} - \frac{u_a \overline{v_{gs}^o} + u_b \overline{m_{gs}^o} + u_s}{1 + \vartheta(u_a^2 + u_b^2)} u_a. \quad (20)$$

In the formula, v_{gs}^{o+1} is equivalent to the final iteration result. The advantage of this method is that it can also detect independent moving targets under the premise of camera movement, so it can work well in two different environments, static background and dynamic background, and has good adaptability.

As shown in Table 1, the characteristics of the interframe difference method, background difference method, and optical flow method are compared.

A wearable device is a portable device that is directly worn on the body or integrated into the user's clothes or accessories. Wearable devices not only are a kind of hardware device but also realize powerful functions through software support, data interaction, and cloud interaction. Wearable devices will bring great changes to our lives and perceptions. After the above theory is complete, we can design the product.

3. Experiments and Conclusions of the Design and Implementation Method of Wearable Products for Intelligent Monitoring of Basketball Training Posture Based on Image Processing

3.1. Demand Analysis of Wearable Products. From the above research, it can be found that the highest incidence of injuries during basketball training is strain. And it does mainly damage to the waist muscles. In the process of running basketball, the muscles are required to explode the maximum energy of the muscles in a short time and the basketball is continuously hit from the floor to the hand. The elbow flexor muscles and the calf flexor muscles exert tremendous power

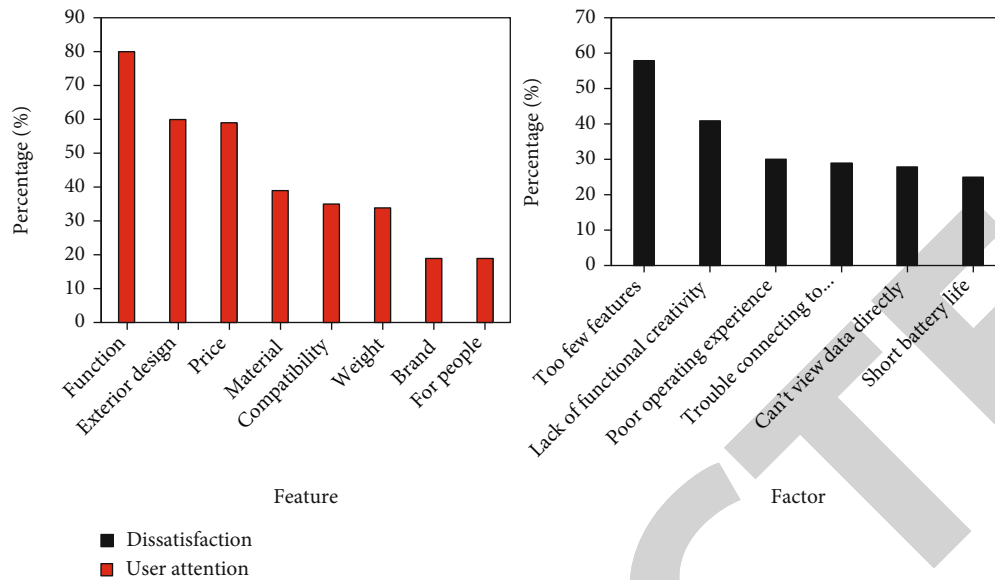


FIGURE 6: Consumers' attention to smart wearable products and dissatisfaction factors.

in a short period of time to complete bounce, hip extension, trunk extension, shoulder shrug, elbow lift, and heel lift. These actions are centered on the core strength, and each part cooperates with each other and is characterized by suddenness and maximum force. During training, trainers often wear exclusive basketball shoes. By restraining the ankle muscles, it improves the core stability, protects the ankle segment, and reduces the pressure on the intervertebral discs, until it protects the spine and prevents injuries. Wearing knee pads for a long time will also make the core muscles of the body lose the opportunity to strengthen and make the core muscles lose the opportunity to learn how to activate the core muscles to stabilize the body. Therefore, the design of basketball wearable products should be different from traditional training equipment and it cannot simply exert force on the muscles for a long time. However, this method is a very subjective method. From the above experimental research, we found that when basketball training, people cannot accurately understand their own muscle state, so that they can formulate scientific training programs based on their physical state. Therefore, it is aimed at basketball. Wearable products need to be able to intelligently analyze the muscle state of the trainer and intelligently generate training plans based on the obtained data, so that the formulation of basketball training can be scientific and effective.

However, many smart wearable products have low practicability, poor quality, and exaggerated publicity, resulting in an increase in the churn rate after users are deceived. The survey is shown in Figure 6.

It can be seen in Figure 6 that clear and fresh functions are the guarantee for the steady progress of the smart wearable product platform. Despite the market demand, the practicability of wearable products still needs to be guaranteed.

3.2. Performance Requirements for Wearable Devices

3.2.1. Parameter Setting. This thesis is based on the basic requirements of wearable, low power consumption, long service life, and stable signal data transmission. A complete set of wearable devices for human sitting posture monitoring, reminding, and exercise status is designed and implemented. By comparing with a foreign equipment with similar functions and for the realizability and rigor of the system, the corresponding parameter indexes are formulated as shown in Table 2.

3.2.2. Transmission Protocol Selection. There are two kinds of data communication protocols between the hardware and the app: one is the low-energy consumption network transmission protocol based on IEEE standard, which requires both the client and the server to have a Zig module for data communication. The second is the low-power Bluetooth communication protocol. The mobile phone itself has a Bluetooth module, so it only needs to integrate the Bluetooth module in the hardware to realize the communication between the device end and the mobile end of the mobile phone. The cost is cheaper and the implementation is more convenient. Therefore, the Bluetooth scheme is preferred in the selection of the data transmission protocol. See Table 3 for the comparison of various forms of wireless transmission protocols and their respective characteristics.

3.3. Product Development and Design. During the prototype development process, the following contents were researched and developed, as follows:

- (1) Realize the Bluetooth connection and binding of software and hardware devices
- (2) Determine and produce the hardware wear methods

TABLE 2: Requirements for various parameters of wearable devices.

Parameter	Index	Safety factor	Reliability
Sampling frequency	110 ms	95.6%	100%
Transmission rate	1.1 Mps	99.5%	100%
Transmission distance	22 M	91.5%	95%
Algorithm execution cycle	1 for 10	92.3%	90%
Transmission delay	4.8 ms	95.5%	100%

- (3) Through the basic data, the relevant data information is extracted and the real-time monitoring function of “head down time is too long” and “dribbling over the wrist” has been completed and the monitoring of the continuous state of sight time has been added
- (4) Through the learning of the step counting algorithm, the algorithm model for monitoring the frequency of dribbling is completed and the real-time monitoring function of the “dribbling rate is too slow” is realized
- (5) Complete the storage of dribble monitoring data and record the trigger time. It is convenient to read historical data to support follow-up experiments
- (6) The modifiable parameters involved in the monitoring algorithm are displayed on the software interface, and the algorithm parameters can be modified on the interface, which is convenient for later experiments

The specific product development process is shown in Figure 7.

It can be seen in Figure 7 that the figure shows the commonly used chips in daily design. After comparison, it can be found that CC2540 has a more convenient control protocol in the communication protocol. At the same time, it also meets the requirements of lower power consumption in the operating voltage, so it is a kind of the ideal choice. The parameter comparison of the three chips is shown in Table 4.

Motion sensor hardware is the basis for the realization of the products described in this research. The performance parameters of the sensors used are shown in Table 5.

3.4. Product Experimental Research. The purpose of this product trial is to test the main function of the product and the monitoring effect of posture monitoring and to collect user reviews.

There are two scenarios in this trial:

3.4.1. Scenario 1. In the real dribble training situation of campus physical education teaching, add a student using the prototype to show the monitoring effect of the product designed in this paper by comparing the effective reminder times of the prototype and the physical education teacher. A total of 4 people were tested.

3.4.2. Scenario 2. In the context of personal training, use the prototype to complete the self-service training and then

complete a related scale. A total of 10 people were tested, including 3 junior high school students, 2 high school students, 5 college students, and 10 people that all have experience in using fitness software; the researcher distributed hardware equipment and software APKs to each test student and conducted simple teaching. The rules of the trial phase are as follows: each person must complete the five training related to the prototype and the single training time for each item is more than 2 minutes. After completion, they can freely operate and view. This scenario will compare the scoring of the prototype and the fitness software. The content of the comparison relates to the attractiveness of the product, the effectiveness of the function, and whether it is easy to stick to it.

3.4.3. Compared with Real Coach Reminders. Through the user trial of the scene, we got relatively positive results.

As shown in Figure 8, the training item is low hand dribbling in situ. The first trial is set as entry difficulty, and the training lasts for 3 minutes and 10 seconds. During the process, the prototype product has monitored 6 times of “too long head lowering time,” 7 times of “too slow dribbling speed,” and 4 times of “dribbling wrists” and the second time of using (with a certain basic entry level) training lasts for 2 minutes and 45 seconds. The training project is in situ low hand dribbling. In the process, the prototype has monitored 8 times of “too long head lowering time,” 10 times of “too slow dribbling speed,” and 8 times of “dribbling wrists” and then studied the times of the prototype and manual reminders in these two cases.

As shown in Figure 8, the prototype reminded the participants 31 times and the coach only reminded the participants 13 times because of the large number of people. By comparison, in the context of group training, the efficiency of product monitoring and prompting is higher than that of coaches, which can more effectively make up for the shortcomings caused by the low teacher-student ratio in group training.

3.4.4. Software Comparison User Score. The user’s score scale has a total of 4 statements. The user scores the prototype product and the fitness software according to the degree of conformity with their psychology. The score ranges from 1 to 5, which is very suitable for 5 points and very unsuitable for 1 point. The specific score is shown in Figure 9.

It can be seen in Figure 9 that positive information was obtained through the trial of this scene. The evaluation of the prototype is generally above the fitness software. There are 10 more people eager to use the prototype product than the fitness software. It is a long-term task whether to develop a good habit of fitness or dribbling. The prototype dribbling training can complete training in a short time, which is more in line with the characteristics of the target user’s busy schoolwork and tight time; relying on the influence of basketball, the prototype can widely cater to the public’s sport preferences. In addition, the subjects showed greater interest and expectations for the monitoring function during training than the simple teaching video playback function.

TABLE 3: Comparison of characteristics of commonly used wireless transmission technologies.

Type	Zig	Bluetooth	Infrared	WiFi	RFID	NFC
Transmission distance	70 m–2.5 km	12 m	<0.2 m	95 m	12 m	1.2 m
Transmission speed	35–245 kb/s	1.2 mb/s	4.1 mb/s	10 mbps–105 mbps	0.5 k	400 k
Working frequency	2.0 GHz	2.0 GHz	*	2.0 GHz	120–130 kHz	12.56 MHz
Incoming power	Low	Middle	*	Low	Low	Low
Anti-interference	Middle	High	High	Low	High	Very high
Agreement	IFEE 800.10.3	IFEE 800.12.1	*	IFEE 800.2.11	*	IFEE 182



FIGURE 7: Product development and design flow chart.

TABLE 4: Comparison of three common wireless communication chip parameters.

Model number	Sleep current	Receiving sensitivity	Agreement	Working voltage
CC25	22 mA/21 mA/0.8 μ A	-90 dbm	ZIG	1.5–3.5 V
NRF101	28 mA/11.0 mA/11.0 μ A	-89 dbm	NONE	1.2–3.3 V
CC251	25 mA/20 mA/0.3 μ A	-91 dbm	BLUETOOTH	1.9–3.3 V

TABLE 5: Performance parameters of each sensor.

Item	Description	Item	Description
Voltage	3.5 V	Resolution	$5.9e - 4.9$ g
Current	<8 mA	Stability	0.001 g
Size	50.1 mm*32 mm*10 mm	Baud rate	104901 kps/8900 kps
Pad pitch	2.44 mm, 14.25 mm	Output frequency	111 Hz/18 Hz
Measurement accuracy	0.045	Data interface	Direct connection MPU5090
Range	+15 g	Measurement dimension	3 dimensions

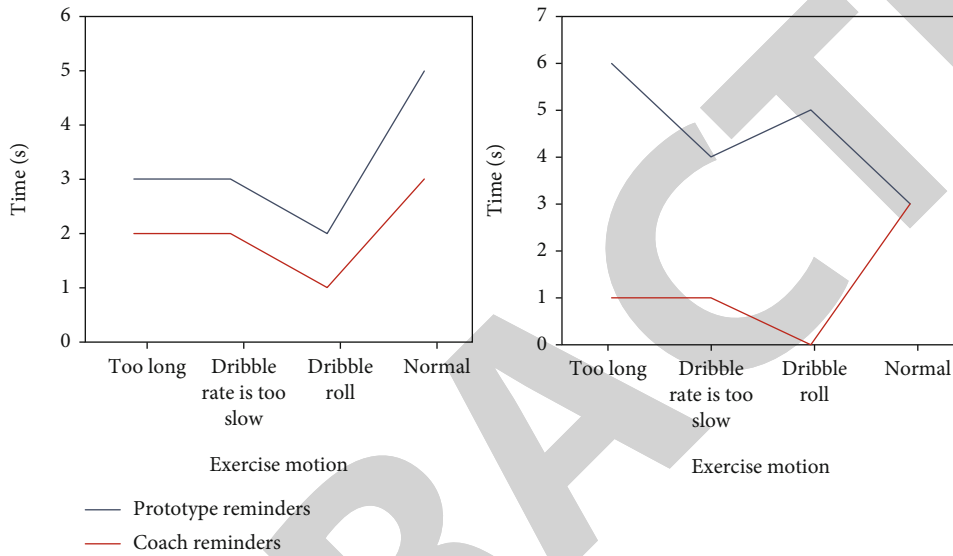


FIGURE 8: Data used twice and the number of reminders.

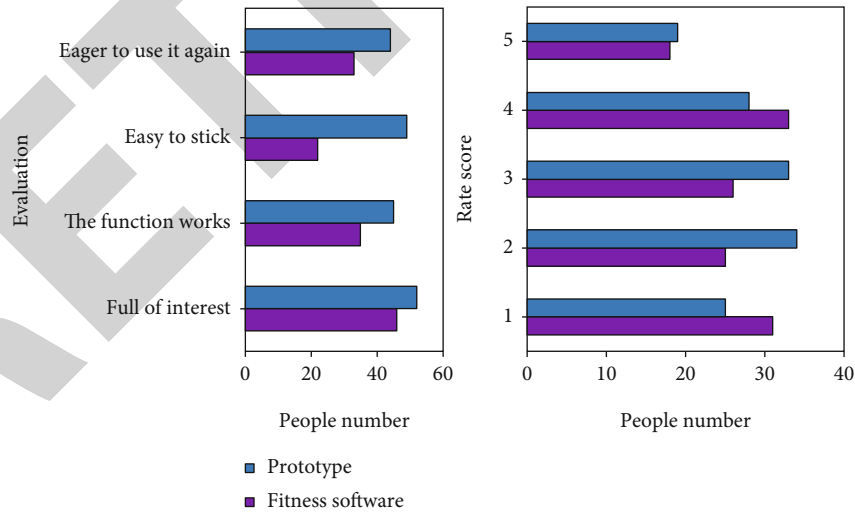


FIGURE 9: Score comparison between fitness software and prototype.

3.5. Data Analysis. In this product prototype, the function of the pedometer installed on the trainer is also to monitor the change of uniaxial continuous acceleration and the number of times the threshold is exceeded to achieve the purpose of stepping. Figure 10 shows 6 groups of experimental data (each group has 80 steps); it checks the corresponding monitoring

system's step taking results and the corresponding step taking accuracy rate. The overall test result shows that the error is within $\pm 1.5\%$, which fulfills the preset requirements in this design and also achieves the purpose of the pedometer design.

It can be seen in Figure 10 that for the 6 groups of test results that are not 100% accurate, there are probably the

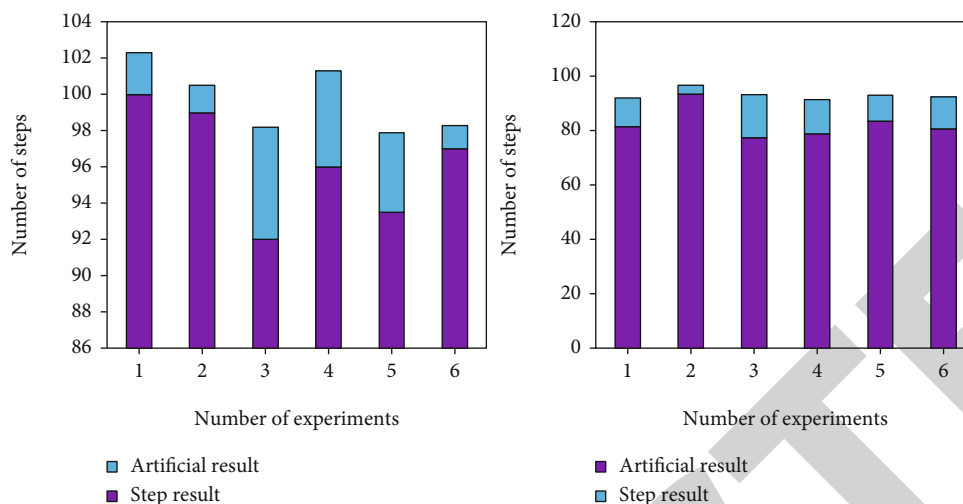


FIGURE 10: Pedometer test results.

following reasons: the relative position of the wearable device will affect the test results and the sensor threshold setting and dynamic performance need to be further improved. Optimization of software algorithms and further improvement of execution efficiency are needed.

4. Discussion

Through continuous iterative optimization, the development of this functional prototype has basically realized all functions except for the graphical function of historical data, and at the same time, the stability of the software has been greatly improved. During the iteration, the author also discovered many operations that can be optimized, such as adding somatosensory interaction to determine whether the currently trained hand is the left hand or the right hand. More importantly, this functional prototype will become the necessary experimental equipment for all subsequent testing and practical processes.

In this article, the author mainly introduces the task flow of high-fidelity prototype development, all the functions and complete experience of high-fidelity prototype, and the trial situation of high-fidelity prototype users. The author developed a product-level prototype software part through a relatively complete product development process and restored the most realistic experience of wearable products according to the conceptual design and analysis part described above. In the final user trial process, the author obtained the effectiveness of the auxiliary training of the wearable product program through tests in two real scenarios: (1) The wearable product program described in this study can effectively compensate for the training in the sport basketball. In dribbling teaching, students cannot get enough posture reminders, which can allow students to get more reminders. (2) Compared with a simple video playback, gesture monitoring and giving reminders are a more favored form of assistant teaching for users, which can more arouse the users' desire to use. (3) And the wearable product designed and developed in this paper is a product that is relatively easy to persist and use for a long time.

5. Conclusions

Through the research and analysis of the basketball training process, this study finds the monitoring method of basketball training technical action. Based on the research of sport science, it combines the sEMG signal acquisition technology with wearable devices to provide a monitoring product for basketball trainers. In order to realize the product design, many scientific methods have been applied, such as the comparison method, data acquisition method, and platform construction method, and the prototype product has been analyzed and developed. Finally, a real-time wearable monitoring product that can act on basketball training posture is integrated and developed. In the context of real dribbling training in campus physical education, experiments are carried out on the wearer. In the context of personal training, the prototype is used to complete self-service training, and then, a relevant scale is completed. On this basis, the basketball training project selects the in situ low hand dribble as the investigation object and takes the reminder times as the final result basis. The duration of the two training sessions are 3 minutes and 10 seconds and 2 minutes and 45 seconds. We found that the prototype reminded the tested athletes 31 times, while the coach reminded them only 13 times. Then, study the subjects and compare their satisfaction scores. If they are very satisfied, give them 5 points, and if they are very dissatisfied, give them 1 point, decreasing in order. It is found that the satisfaction evaluation of the prototype is based on the fitness software and more than 10 people want to use the product prototype designed in this paper again, which shows that the public satisfaction of the prototype is guaranteed. The shortcomings of this paper are as follows: firstly, due to the limited experimental conditions, the product level miniaturized motion sensor module can not be obtained, which makes the design reduction of the hardware part of wearable devices low. Secondly, because of the time conditions, the number of subjects involved in the experiment and trial in this study is relatively small and more subjects should be added in the later research. Therefore, in the next research, finding a larger experimental

platform and adding more testers are the problems we want to solve, so that our products can be developed and applied in a broader field.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there is no conflict of interest with any financial organizations regarding the material reported in this manuscript.

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