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Retraction

Retracted: Designing and Implementing a Terminal Platform to Manage and Detect the Health of Exercise Parameters Based on Internet Objects

Journal of Sensors

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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] X. Bai, "Designing and Implementing a Terminal Platform to Manage and Detect the Health of Exercise Parameters Based on Internet Objects," *Journal of Sensors*, vol. 2022, Article ID 7121741, 10 pages, 2022.

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Research Article

Designing and Implementing a Terminal Platform to Manage and Detect the Health of Exercise Parameters Based on Internet Objects

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In order to realize the research on vital signs monitoring based on the Internet of things, in view of the urgent needs for mobile health and universal medical treatment in China, this paper puts forward the platform design and implementation of exercise parameter health management and detection terminal based on the Internet of things. Firstly, the overall architecture of the exercise heart rate monitoring system is designed, and the design of the heart rate acquisition module is also put forward, in order to monitor human heart rate data conveniently, quickly, and in real time, considering the portability and low power consumption of the system, a wearable heart rate real-time monitoring system is designed in this paper. The experimental results show that the maximum individual average heart rate difference is 4.11 bpm and the overall average heart rate difference is 2.24 bpm. After processing with the adaptive hybrid filtering algorithm, the maximum individual average heart rate difference is 0.69 bpm, and the overall average heart rate difference is 0.42 bpm. The average standard deviation of the difference between the 10 groups of measured values and reference values with and without the filtering algorithm is 0.304 and 2.788, respectively, which is about 9 times higher. The accuracy and stability of the filtering algorithm are greatly improved. The whole system can run well and can be applied to practical sports training guidance.

1. Introduction

The term "mobile Internet" refers to the worldwide network that users use through wireless mobile devices such as cell phones and PDAs. Mobile Internet provides a seamless connection between time and place. Users can use mobile terminals to enjoy various services such as instant messaging and file downloading. The characteristics of the mobile Internet are reflected not only in mobility, which allows users to use Internet services "anytime, anywhere, and at will," but also in the rich business types, personalized services, and the guarantee of higher service quality. Of course, mobile Internet is also subject to certain restrictions in network and terminal. The features are as follows: terminal mobility: mobile Internet enables users to access and use Internet services on the move; access diversity: there are various access modes for mobile Internet users. The emergence of WIMAX, WIFI, 3G, and other technologies provides wireless access support for terminals. The transmission capacity and stability of different access modes are also different. The limitation of the terminal and network are as follows: in terms of network capability, it is limited by factors such as wireless network transmission environment and technical capability. The terminal capacity is limited by terminal size, processing capacity, battery capacity, etc. The strong correlation between business and the terminal and network is as follows: mobile Internet is limited by network and terminal capabilities, and its business content and form should also be suitable for specific network technical specifications and terminal types. The privacy of business use is as follows: most of the information transmitted by mobile devices in the communication process is private information. When using mobile Internet, the content and services used are more private, such as mobile payment business. Maintaining a healthy body requires not only a reasonable diet but also scientific exercise habits. A large number of studies have proved that regular aerobic exercise is beneficial to human health and can improve human exercise ability and physical quality. In terms of health results and the effectiveness of intervention programs, the accurate quantification of physical exercise and physical health is very important [1]. If we can collect and analyze human health information and exercise information, we can give effective guidance and intervention in exercise and health. At present, the collection of health and exercise information has experienced four development stages. The first stage is the manual collection stage, which mainly collects and records human body information manually [2]. The second stage is the electronic acquisition stage, which measures the relevant information on the human body through electronic equipment, but at the same time, it needs to record the data manually and then analyze and save the data. Common measurement methods include a pedometer, pulse meter, and sphygmomanometer. People's movement steps can be quickly measured through a pedometer. The pulse meter can measure human pulse information, and the sphygmomanometer is used to measure human blood pressure. The third stage is the network acquisition stage, which uses electronic equipment to detect human body-related information and then uses various networks (such as the Internet) to transmit the detected data, so as to realize the automatic collection and upload of data and facilitate the application of users. The fourth stage is the ubiquitous acquisition stage, that is, the application mode of combining a wireless network with a web server or a wireless network with a mobile client [3]. Figure 1 is the research flow chart of the exercise heart rate monitoring system. Mobile Internet has entered the initial stage of industrialization, the traditional Internet cannot well support the mobility of users, and the traditional mobile communication network is not designed for data and multimedia services, so the integration of the two will inevitably bring many new challenges [18]. The era of the mobile Internet is an era of integration and the era of industries entering each other. The development of technology will promote the evolution of the traditional telecom industry to the big ICT industry integrating the Internet media, entertainment, and other industries. The application of computing technology will bring a brand new driving force to the development of the mobile Internet. Data transmission methods applied in portable devices include both traditional wired transmission methods and current wireless transmission methods, such as WiFi, RFID, Bluetooth, ZigBee, and other technologies [4]. These communication methods have their own advantages and disadvantages, among which the biggest disadvantage of wired communication is limited by the connecting line, and the communication distance is very limited. The wireless transmission mode needs to choose the appropriate wireless technology according to the specific application, and the research in this field has attracted more and more attention. Based on the current research, this paper proposes an adaptive hybrid filtering algorithm, which can not only effectively filter accidental interference but also suppress periodic interference [5]. The architecture of the sports heart rate monitoring system was designed and proposed based on the cutting-edge technology of the Internet of things. The

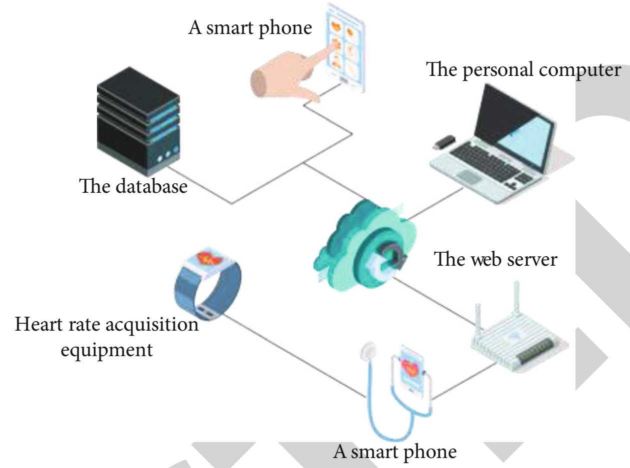

Figure 1: Research flow chart of the exercise heart rate monitoring system.

system mainly includes the heart rate acquisition part, heart rate analysis service, and heart rate monitoring application. A heart rate acquisition device is made by using a pulse sensor to collect the heart rate of athletes in different states. It is required that the device can realize real-time heart rate acquisition, adaptive hybrid filtering of heart rate value, and complete wireless communication with a mobile terminal using Bluetooth low power consumption. The exercise heart rate, heart rate load, and exercise were studied, the personalized maximum heart rate evaluation method and exercise load index model were put forward, and the problem of a huge error in calculating the maximum heart rate with a single fixed formula was solved. It realizes the long-term monitoring of exercise heart rate. The real-time heart rate can only be used as a heart rate alarm. Through the long-term monitoring of exercise heart rate, it can better analyze various heart rate indicators of athletes, help athletes understand their exercise status, and make corresponding adjustments to the exercise plan in time. In order to realize the research on vital signs monitoring based on the Internet of things, in view of the urgent needs for mobile health and universal medical treatment in China, this paper puts forward the platform design and implementation of exercise parameter health management and detection terminal based on the Internet of things. Firstly, the overall architecture of the exercise heart rate monitoring system is designed, and the design of the heart rate acquisition module is also put forward, in order to monitor human heart rate data conveniently, quickly, and in real time, considering the portability and low power consumption of the system; a wearable heart rate real-time monitoring system is designed in this paper.

2. Literature Review

Aiming at this research problem, Jia and others designed a system to collect physiological data based on a WiFi controller. The system can detect temperature and heart rate and transmit information to the PC according to a wireless WiFi protocol to realize effective monitoring of temperature and heart rate parameters [6]. Kim and others designed an Internet of things pedometer based on the ZigBee technology. The acquisition terminal uses the accelerometer to collect motion information, transmits the data to the computer through the ZigBee transmission network, and realizes the functions of step statistics, user management, and energy consumption estimation through the computer [7]. Chen and others designed the pulse acquisition node and body temperature acquisition node based on the ZigBee technology to collect the pulse and body temperature of a human body. The RF chip CC2430 has attracted people's attention [8]. Cambiaso designed a system for collecting physiological data based on a WiFi controller. The system can detect temperature and heart rate and transmit information to a PC according to the wireless WiFi protocol to realize effective monitoring of temperature and heart rate parameters [9]. Zhang and others used AT89C51 as the microprocessor, selected the temperature sensor DS18B20 to detect the body temperature, and sent it wirelessly through the wireless transceiver chip nRF401, and the computer received the body temperature data and processed and displayed it to achieve the purpose of real-time monitoring [10]. Thibaud and others collected human walking parameters with accelerometers and analyzed the motion signal of the same test user under asynchronous speed. It was concluded that the walking acceleration signal was a periodic signal, and its frequency and amplitude would increase when the running speed was accelerated [11]. Chenyin and Feng analyzed the behavior characteristics of human walking in detail, established the human walking model, measured the parameters of human walking with adxl330, and finally proposed an adaptive pedometer algorithm to estimate the number of steps during walking [12]. Cao and others analyzed the behavior characteristics of people when walking or running, used the acceleration sensor to detect the acceleration of human movement, obtained the algorithm of walking steps, and obtained the walking distance from the stride, using the sensor adxl340 [13]. Liu and Xiao analyzed the characteristics of walking or running as related parameters and plotted the relationship between each stage of the walking cycle and the change of vertical and forward acceleration. The movement can be divided into three directions, namely the x-axis direction, y-axis direction, and z-axis direction. Adxl345 is used to detect acceleration in three directions, and the designed full-function pedometer can identify and count the pace and measure the distance, speed, and even calories burned [14]. Sardjono et al. mainly study how to apply the existing resource-sharing technology to the mobile phone and mobile network, according to the characteristics of the mobile phone network, and modify and develop a mature resource-sharing system to better adapt to the mobile network [15]. Sheth et al. implemented the peer-to-peer file sharing service software for mobile terminals, which provides users with open search methods and download functions. In addition, the file copyright recognition technology was integrated to identify the copyrighted content and charge for it [16]. There are many architectures for the Internet of things. The smart city proposed by IBM is a broad prospect for the application of the Internet of things. The basic function of the Internet of things is to connect objects. Whether things to things, machines to machines, or people to things and things to people, it is a description of the Internet of things from a certain angle. We can flexibly choose the appropriate system architecture according to the needs of the system, so we do not compare the advantages and disadvantages of various Internet of things architectures here.

In order to realize the research on vital signs monitoring based on the Internet of things, in view of the urgent needs for mobile health and universal medical treatment in China, this paper puts forward the platform design and implementation of exercise parameter health management and detection terminal based on the Internet of things. Firstly, the overall architecture of the exercise heart rate monitoring system is designed, and the design of the heart rate acquisition module is also put forward, in order to monitor human heart rate data conveniently, quickly, and in real time, considering the portability and low power consumption of the system; a wearable heart rate real-time monitoring system is designed in this paper.

3. Method

3.1. Overall Architecture of the Exercise Heart Rate Monitoring System

3.1.1. This Paper Refers to the Internet of Things Architecture. The Internet of things architecture referred to in this paper can be divided into three layers: perception layer, network layer, and application layer. The sensing layer is composed of various sensors and the technical architecture of the sensor gateway structure, including carbon dioxide concentration sensor, temperature sensor, humidity sensor, QR code tag, RFID tag and reader/writer, camera, GPS, and other sensing terminals. It also includes vital sign acquisition terminals such as a heart rate meter, sphygmomanometer, and blood glucose meter. The function of the perception layer is equivalent to the nerve endings of the human eyes, ears, nose, throat, and skin. It is the source of the Internet of things to identify objects and collect information. Its main function is to identify objects and collect information. The network layer is composed of various private networks, the Internet, wired and wireless communication networks, network management systems, and cloud computing platforms. It is equivalent to the human nerve center and brain, which is responsible for transmitting and processing the information obtained by the perception layer. The application layer is the interface between the Internet of things and users (including people, organizations, and other systems). It combines with the needs of the industry to realize the intelligent application of the Internet of things. The Internet of things is widely used, including warehousing and logistics, intelligent transportation, intelligent buildings, environmental monitoring, industrial safety, medical care, and smart home [17]. The application of the exercise heart rate monitoring system belongs to the vital sign monitoring part of intelligent health, which can be divided into medical care.

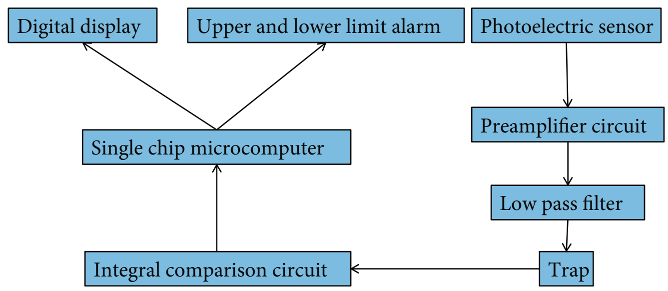

Figure 2: Heart rate acquisition equipment.

3.1.2. This Paper Introduces the Overall Architecture of the System. The motion heart rate monitoring system in this paper uses the heart rate acquisition device made by "pulse sensor + ticc2540" as the sensor node in the sensing layer. Use an Android mobile phone as a sensor gateway, communicate with a heart rate acquisition device through Bluetooth on the Android mobile phone, and communicate with the web server through the HTTP protocol. Android application software for exercise heart rate monitoring and exercise heart rate monitoring website is used as the application layer [18].

The exercise heart rate monitoring system involves embedded, Android, web applications, and other related technologies and should organically combine all parts into a coordinated system to jointly complete the exercise heart rate monitoring service. On the whole, the system is divided into three parts: the heart rate acquisition module, Android application, and web service [19].

3.2. Design of the Heart Rate Acquisition Module. The heart rate acquisition equipment shall complete the real-time heart rate acquisition. First, collect the pulse information, and then obtain the time t of each pulse from the pulse information. The heart rate $\mathrm{HR} = 60/T$ uses the heart rate filtering algorithm to filter the collected heart rate information numerically. Finally, communicate with the smart phone through Bluetooth and send the filtered data to the mobile phone [20]. The hardware framework design of the heart rate acquisition module is shown in Figure 2.

The production of heart rate acquisition equipment should complete the design of hardware and software. The pulse sensor used in this system is a foreign open-source hardware sensor, which has been introduced into China in recent years. It can sample the light environment of human finger blood flow. 80C51 controls the AD converter to the sample pulse analog signal to obtain pulse data and calculate the heart rate according to pulse period T [21].

3.3. Design of the Mobile Application of the Exercise Heart Rate Monitoring. The exercise heart rate monitoring system in this paper initially uses an Android mobile phone as the mobile terminal device. The application on the Android mobile phone is an important part of the exercise heart rate monitoring system. The Android application should complete the communication with the heart rate acquisition terminal, collect the information related to the athlete, display the athlete's heart rate information and exercise status, and assist the athlete to complete the training plan [22].

3.3.1. Mobile Application Function Design. The exercise heart rate monitoring system can design very rich functions in the mobile terminal. This paper is only aimed at the research goal and designs the application software of the mobile terminal according to the basic requirements of the system.

The mobile phone application is an important part of the interaction between the exercise heart rate monitoring system and users in this paper. The mobile phone application software in this paper is divided into three modules: heart rate acquisition and management, user information management, exercise target management, and exercise heart rate monitoring [23]. The resting heart rate collection of the heart rate collection module refers to the heart rate collected when the athlete wakes up early. This system realizes the real-time collection of heart rate. The resting heart rate takes the average value of 30 heart rates. In the Android application interface, a button is designed separately to collect the resting heart rate. The acquisition of exercise heart rate is generally related to the completion process of the exercise target. The exercise heart rate is measured when the exercise warms up. The exercise heart rate measurement adopts the time interval to average the collected heart rate every 5 s and stores it in the JSON file, but each collected heart rate will be displayed in the view real-time heart rate part of the exercise heart rate monitoring module. User information management has an exercise load setting and an important form to fill in, including gender, health, and professional training. This form is mainly to assist the athlete to complete the estimation of the maximum heart rate. Of course, if the athlete has measured his maximum heart rate, he can directly set the maximum heart rate. The purpose of sports goal management is to assist the athlete to complete the sports plan. You can view the long-term sports plan formulated by the athlete or the coach or set the goal of each exercise. The content of the goal includes the form of exercise, exercise time, the maximum heart rate reached by this exercise, and the average exercise heart rate. After exercise, the completion degree of the target can be judged according to the heart rate statistics collected during exercise. The statistical chart of multiple moving targets can be viewed on the mobile app, which can evaluate the completion of long-term motion planning. The exercise heart rate monitoring part can set the heart rate alarm, which completes

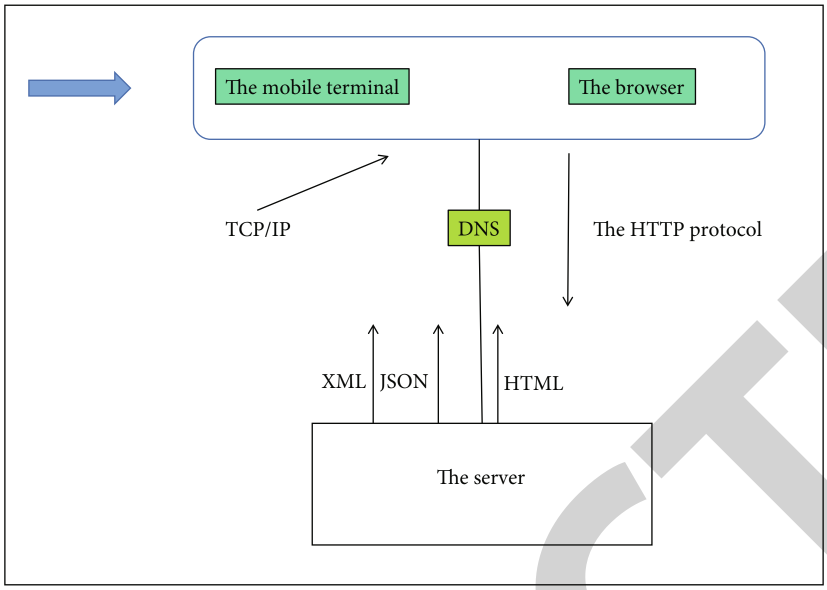

Figure 3: Communication between the client and server.

the real-time heart rate monitoring. The athlete can adjust the exercise intensity at any time according to the real-time heart rate, and the heart rate alarm is designed to avoid too low or too high exercise intensity before exercise [24]. If you are exercising indoors, you can view your load statistics chart and heart rate curve in real time during the exercise. The function design of the mobile application can fully meet the research goal of this paper, which is very simple and practical. The function of viewing friend information is added to the user information management, in order to provide users of the exercise heart rate monitoring system with a window of friend comparison and encourage athletes to complete the exercise goal.

3.3.2. Design of Mobile Communication and Data Storage. This paper uses Android technology to complete the functional design of the mobile application. There are several key points to be explained clearly in the process of application development. This system uses the BLE protocol to complete the communication between the mobile phone and heart rate acquisition device. In the design of this system, an Android mobile phone is used as the host device and the heart rate acquisition device as the slave. In ATT and GATT protocols, Android phones play the role of the client, and heart rate acquisition devices play the role of the server. In the gap protocol, Android phones play the role of central, and heart rate acquisition devices play the role of peripheral. In this paper, the system will use the Bluetooth "notification" function to send the collected heart rate data to the android app application through the occurrence of OSAL periodic events. It should also be noted that the Android mobile terminal of this system is the intermediate node between the heart rate acquisition device and the web server. Although the data persistence part of this system is designed on the server, the Android terminal still needs to maintain some temporary data, such as the basic information of the local user and the heart rate data recorded by the local user on that day. The application of this mobile terminal uses JSON to save the heart rate data of that day. Heart rate data can be saved on the mobile phone for one month. Users should synchronize the data to the web server in time. Android uses the HTTP protocol to communicate with web server. Android application is one of the main sources of system data. In the design of this system, JSON is used to transmit data between the Android application and the web server. The mobile phone is one of the clients of web services. The communication between client and server is shown in Figure 3.

3.4. Analysis of Heart Rate Filtering. In the process of data acquisition, heart rate acquisition equipment will inevitably be affected by some periodic and aperiodic interference signals from the system itself and the external environment, such as user breathing, muscle jitter, baseline drift, and power frequency interference. At present, there are two ways to process interference signals: hardware filtering and software filtering. The simple use of hardware filtering has the disadvantages of fixed cut-off frequency, unsatisfactory filter rectangular coefficient, and relatively poor accuracy, which cannot completely suppress the influence of the system itself and the external environment. Therefore, it is necessary to use an effective software filtering algorithm to suppress or eliminate the influence of various signal interference in the process of signal acquisition, so as to make the heart rate monitoring data more reliable [25]. In order to monitor human heart rate data conveniently, quickly, and in real time, considering the portability and low power consumption of the system, a wearable heart rate real-time monitoring system is designed in this paper. Based on the experimental test and analysis, an adaptive hybrid filter algorithm is proposed to improve the reliability of real-time monitoring of the system and realize the long-term real-time monitoring of exercise heart rate [26].

3.5. Adaptive Hybrid Filtering Algorithm. In the numerical filtering algorithm, different filtering algorithms are usually adopted according to the different characteristics of interference signals, so as to achieve a better filtering effect. Common numerical filtering algorithms are as follows: (1) amplitude limiting filtering method cuts the sampling value by setting the threshold to make it not exceed the threshold range. It can effectively overcome the singular signal interference caused by accidental factors, but it has a poor suppression effect on periodic interference signals and poor smoothness. (2) The median average filtering method can suppress the accidental pulse interference and eliminate the sampling value deviation caused by it. (3) The recursive average filtering method has a good inhibitory effect on periodic interference, but it has a poor inhibitory effect on accidental signal interference and a high degree of smoothness. In the median average filtering method and recursive average filtering method, the selection of the sampling value window size will also affect the filtering effect. A large window means high smoothness and low sensitivity. A small window means poor smoothness and high sensitivity. In view of the above analysis, the combination of the amplitude limiting filtering method, recursive median average filtering method, and recursive average filtering method is adopted, and according to the influence of the size of the sampling value window on the filtering effect, an adaptive hybrid filtering algorithm is proposed, which can effectively filter out accidental interference and suppress periodic interference.

In the adaptive hybrid filtering algorithm, W_n is the window size of the nth sampling queue. The adjustment of W_n value needs to be judged. When $n\%m = 0$ is met, W_n adjustment is carried out once, where m is the W_n adjustment step set by the system. Under normal circumstances, the deviation between the previous sampling value and the later sampling value is very small. Therefore, if the absolute value of the difference between two adjacent values in the sample queue is greater than the maximum sampling deviation set by the system, it indicates that there is an abnormal fluctuation during heart rate acquisition.

$$C_i = \begin{cases} 1, |S_i - S_{i-i}| \succ S_A \\ 0, |S_i - S_{i-1}| \leq S_A. \end{cases} \quad (1)$$

In formula (1), 1 indicates abnormal fluctuation, 0 indicates no abnormal fluctuation, and S_A is the maximum sampling value deviation.

Adaptively adjust the corresponding window size according to the number of abnormal fluctuations in the sampling value queue. When there are many abnormal fluctuations, increase the queue window, improve the smoothing effect, and suppress the interference. Reduce the number of abnormal fluctuations, reduce the queue window, reduce memory consumption, and improve the operation speed.

The maximum heart rate is the number of rhythmic contractions of the heart per minute. The international general maximum heart rate calculation formula is used to limit and filter the heart rate for the maximum heart rate of the human body and the minimum heart rate set by the system: if the measured value is greater than the minimum heart rate and less than the maximum heart rate, the sampling value is valid. If the sampling value is greater than the maximum heart rate or less than the minimum heart rate, the sampling value is invalid [27]. Discard the sampling value and use the historical measurement average as the measurement value. If the measured value is invalid for 3 consecutive times, initialize all operations, and restart the measurement. The measured value of heart rate through amplitude limiting filtering is S_n

$$S_n = \begin{cases} F_n, H_{\min} \leq F_n \leq H_{\max} \\ F_c, F_n \succ H_{\max} or F_n \prec H_{\min}, \end{cases} \quad (2)$$

$$H_{\max} = 220 - \text{age}. \quad (3)$$

In Equation (2), F_n is the nth heart rate measurement value and F_c is the historical average value. In Equation (3), $H_{\min}$ is the minimum heart rate set by the system, $H_{\max}$ is the maximum heart rate, and age is the age of the tester.

Add the heart rate measurement value after limiting the filtering algorithm to the queue for recursive median average filtering. According to the first in first out principle, add the measured new value to the tail of the team, and throw away the data of the head of the team. According to the size of the queue window, remove the maximum and minimum values in the queue, calculate the arithmetic average of the remaining $(W_n - 2)$ data as the recursive median average filtering output, and update the historical measurement average. The heart rate measurement value filtered by the recursive median average is

$$T_n = \frac{1}{W_n - 2} \sum_{i=0}^{W_n - 1} \left(S_{(n-i)} - S_{(n-i)\,\max} S_{(n-i)\,\min} \right). \quad (4)$$

In Equation (4), $S_{(n-1)}$ is the measured value of the $(n-i)$ th heart rate after amplitude limiting filtering, and $S_{(n-1)\,\max}$ and $S_{(n-1)\,\min}$ are the maximum and minimum values of the measured value of queue center rate, respectively. In order to further improve the stability of the heart rate acquisition system, the algorithm uses quadratic recursive average filtering. Recursive average filtering belongs to low-pass filtering, which can make the cut-off frequency smaller and filter out the high-frequency signal with relatively low frequency.

$$H_n = \frac{1}{W_n} \sum_{i=0}^{W_n - 1} T_{(n-i)}. \quad (5)$$

In Equation (5), H_n is the recursive average filtered output value, that is, the final heart rate measurement value.

4. Results and Analysis

4.1. Calculation of Maximum Heart Rate. It is generally accepted by athletes and coaches to formulate training programs according to the changes of heart rate. A large number of studies on heart rate and exercise load show that there is a linear relationship between exercise intensity and heart rate, and the exercise load level can be divided according to the different ranges of maximum heart rate. The maximum heart rate is not a fixed value. It will change with the physical condition of the athlete. For example, the decrease of training intensity or the halting of training of professional athletes will lead to an increase in the maximum heart rate. The maximum heart rate obtained by the same athlete using different measurement methods is quite different. When studying how to calculate the maximum heart rate, we should give corresponding calculation methods for different people and different exercise states.

4.1.1. Maximum Heart Rate Measurement. Through the investigation of some gyms around, it is found that half of the gyms publicize the concept of maximum heart rate to fitness lovers, and some treadmills can directly monitor heart rate. Through observation, ordinary fitness enthusiasts do not pay attention to the importance of heart rate in fitness, while professional athletes or senior fitness enthusiasts will measure the maximum heart rate and bring a heart rate meter or heart rate belt to detect their exercise status. There are two commonly used methods to measure the maximum heart rate, namely, the power vehicle load increasing method and the treadmill load increasing method.

The power car load increasing test method selects a small power that the subject feels comfortable with (such as 30 W for men and 25 W for women), keeps the pedaling frequency straight at 60 rpm, and then increases the load every 3 minutes. The initial increase range is 20 W. When the subject begins to feel tired, increase the range every 1 minute, about 5 W, and stop the test until the subject is exhausted or has symptom limitations. The real-time heart rate monitor is used to monitor the change of the subject's heart rate in the whole process to obtain the maximum heart rate value. In the treadmill load increasing test, the exercise speed is fixed at 4.8 km/h, and the slope increases by 5 degrees every 2 minutes until the test is stopped when the subject is exhausted or limited by symptoms. For healthy middle-aged people, first, use the power car load increase test to screen out suitable subjects, then carry out the power car load increase test on qualified subjects according to the test plan to obtain HR max, and carry out the treadmill load increase test to obtain another HR max. Through a large number of experimental comparisons, it is found that there are obvious differences between the results measured by the two methods. The results measured by the bench test are significantly higher than that of the power vehicle test. The experimental results are shown in Table 1.

Table 1: Statistics of maximum heart rate measurement results.

Power car test		Treadmill test	
Number of people	Maximum heart rate	Number of people	Maximum heart rate
9	167.32 ± 12.67	9	171.43 ± 11.06
11	164.01 ± 12.34	11	173.08 ± 8.69
20	164.74 ± 13.04	20	172.34 ± 9.59

The maximum heart rate measured by the maximum heart rate may not reflect the real state of the athlete's physical function. Different test methods will get different results. The maximum heart rate is not a fixed value at all. It changes dynamically. Therefore, the use of fixed formula has great limitations.

4.1.2. Design of the Personalized Maximum Heart Rate Calculation Method. When it comes to individuals, there is a big deviation in using a fixed formula to calculate the maximum heart rate. This paper attempts to study a personalized maximum heart rate calculation method to ensure that the maximum heart rate can be consistent with the physical condition of the athlete, so as to ensure the rationality of dividing the exercise load index according to the maximum heart rate. The calculation of an individual personalized maximum heart rate must consider the actual physical function of the individual, and the calculation results reflect the maximum exercise load that the body can bear in a certain period of time. The maximum load that an individual can bear is relatively stable under normal circumstances. The maximum heart rate will change accordingly only when the physical function of the athlete changes qualitatively on the basis of sufficient quantitative change. The improvement of the physical function of athletes can bear the increase in exercise load, but the maximum heart rate does not necessarily increase. Facts have proved that in the long run, the maximum heart rate of professional athletes with long-term special training is relatively low. This paper holds that the main factors affecting the maximum heart rate are age, health status, gender, and training level. This paper designs a maximum heart rate calculation method, which starts from selecting the maximum heart rate calculation formula, because selecting the appropriate calculation formula can be closer to the real value in the first step. The first step is to fill in the information of age, health status, gender, and training level. The second step is to divide users into corresponding groups according to the collected information and select the calculation formula of maximum heart rate applicable to the corresponding groups. The third step is to adjust the maximum heart rate according to the athlete's pre in a short time. Pre is the subjective feeling of movement. The fourth step is to make further corrections according to the health level and training status of athletes in the subsequent long-term monitoring.

Among the four main factors, age should be considered in each case. The population is divided into eight categories according to health status, gender, and training level, corresponding to eight fixed maximum heart rate calculation formulas. In the application design, the health status, gender, and training level shall be filled in a fixed order, corresponding to the fixed number, respectively. The corresponding relationship of the heart rate calculation formula selected

Table 2: Calculation formula of maximum heart rate selected in this paper.

Athlete status	Number	Calculation formula of maximum heart rate
Healthy male training	111	206 – 0.71 × age
Healthy male nontraining	110	212 – 0.7 75 × age
Healthy women training	101	216 – 0.88 × age
Healthy female nontraining	100	208 – 0.7 × age
Nonhealthy male training	011	198 – 0.41 × age
Nonhealthy male non training	010	209 – age
Nonhealthy female training	001	196 – 0.9 × age
Nonhealthy female nontraining	000	210 – 0.66 × age

Table 3: Various indexes of exercise intensity.

Classification of exercise intensity	Maximum heart rate	Maximal oxygen uptake or maximal heart rate reserve	Subjective physical feeling inner table
Lower strength	<35%	<30%	<9
Low strength	35%~59%	35%~49%	10~11
Medium strength	60%~79%	50%~74%	12~13
High strength	80%~89%	75%~84%	14~16
Super strength	≥90%	≥85%	>16

for different groups is shown in Table 2. The basic principle of selecting the formula is to be as close to reality as possible, but the formula with small calculation results shall be selected for nonhealthy people within a certain range. This can better protect the sports safety of sports users, that is, the criterion of selecting the initial calculation formula in this paper is to optimally consider the sports effect for healthy athletes, and give priority to sports safety for nonhealthy athletes.

After selecting the calculation formula of the maximum heart rate, an initial maximum heart rate is obtained. The athlete starts training according to the exercise load level divided by the maximum heart rate and adjusts the maximum heart rate according to the subjective physical feeling. Each adjustment can add or subtract 5. Before using pre feedback to adjust the maximum heart rate, athletes should be familiar with the use of pre sensory table. The corresponding relationship of various indexes of exercise intensity is shown in Table 3.

The exercise heart rate reflects the exercise load intensity of the athlete. The maximum heart rate can reflect the physiological maximum stress level of the athlete. The heart rate reserve obtained by subtracting the resting heart rate from the maximum heart rate reflects the variation range of the athlete's heart rate. The maximum heart rate will not change in a short time, but after long-term training or long-term stop training, the athlete's maximum heart rate will change accordingly. This paper proposes a personalized maximum heart rate calculation method, which can well reflect the physical function level of athletes on the basis of ensuring the exercise effect and safety of athletes.

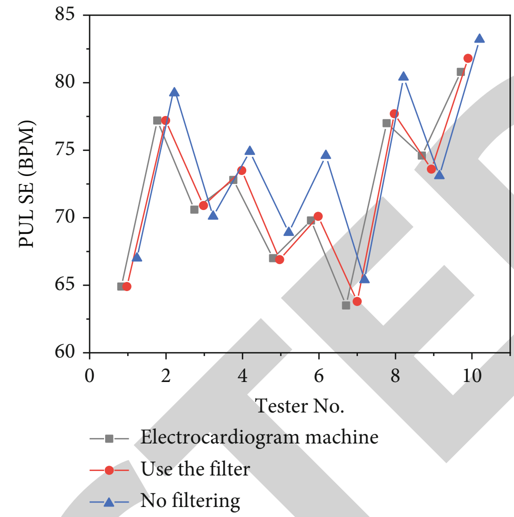

Figure 4: Comparison of average heart rate and standard deviation of three groups of measured values.

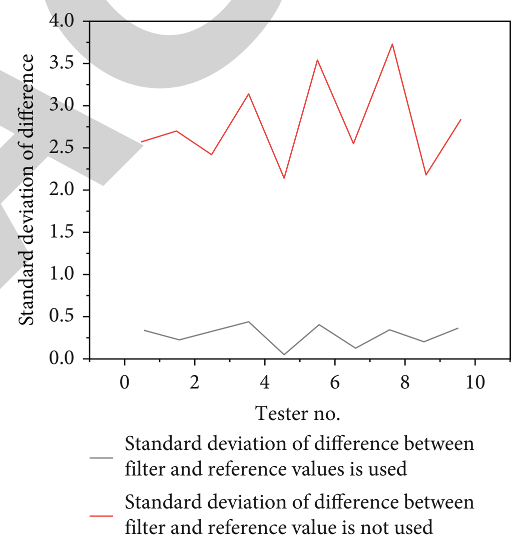

Figure 5: Standard deviation of the difference between used and unused filter and reference value.

4.2. Experimental Analysis. The adaptive hybrid filtering algorithm proposed in this paper is tested. Hk-2000a is used as the piezoelectric pulse sensor, the pressure range is -50-+300 mmHg, and the pulse signal is output. The high level is greater than 1.5 V, and the low level is less than 0.2 V. Ti cc2540 SOC (system on chip) is as follows: 8051 as the core, 128 K flash, 8 K RAM, and ble4.0 on-chip antenna. 12864LCD is used as the display output. The Android system is version 4.4 and supports ble4.0 xiaomi3 as the mobile terminal.

In order to test the effect of using an adaptive hybrid filtering algorithm on improving the measurement accuracy of the system, the heart rate synchronously recorded by a three-channel ECG machine (Bangjian ecg-3010) is selected as the reference standard to evaluate the accuracy of the system. The measurement results with and without the adaptive hybrid filtering algorithm are compared with the reference standard. In the experiment, 10 subjects were measured, including 6 males, aged between 25 and 49, and 4 females, aged between 22 and 44. The test condition was sedentary and lasted for 10 minutes. The average heart rate and standard deviation are calculated according to the three groups of measured values of the ECG machine and equipment with and without the adaptive hybrid filtering algorithm. The standard deviation of the difference between the measured value and the reference value with and without the filtering algorithm is calculated. The results are shown in Figures 4 and 5.

The results show that the maximum individual average heart rate difference is 4.11 bpm and the overall average heart rate difference is 2.24 bpm without using the adaptive hybrid filtering algorithm. After processing with the adaptive hybrid filtering algorithm, the maximum individual average heart rate difference is 0.69 bpm, and the overall average heart rate difference is 0.42 bpm. The average standard deviation of the difference between the 10 groups of measured values and reference values with and without the filtering algorithm is 0.304 and 2.788, respectively, which is about 9 times higher. The accuracy and stability of the filtering algorithm are greatly improved. The accuracy and stability of the filtering algorithm are greatly improved. The whole system can run well and can be applied to practical sports training guidance.

5. Conclusion

This paper puts forward the platform design and implementation of exercise parameter health management and detection terminal based on the Internet of things. This paper designs and implements a practical exercise heart rate monitoring and analysis system to provide reliable and stable heart rate monitoring services for athletes. The system can monitor the dynamic change of heart rate in real time and monitor the fitness exercise according to the relevant information on heart rate and the personalized heart rate load index model. The system helps athletes adjust the exercise intensity in time, formulate, and complete the exercise plan, so as to achieve the ideal exercise effect. Through the long-term monitoring of exercise heart rate, it can better analyze various heart rate indicators of athletes, help athletes understand their exercise status, and make corresponding adjustments to the exercise plan in time. It is hoped that in the future work, with the accumulation of knowledge and experience, we can obtain more resources, further optimize and improve the exercise heart rate monitoring system, make the exercise heart rate monitoring system better provide exercise load monitoring services for athletes, and make the data collected by the long-term monitoring of the exercise heart rate monitoring system become the basic data of exercise heart rate research.

Data Availability

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

Conflicts of Interest

The author declares no conflicts of interest.

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