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Research Article

Exercise and Rehabilitation of Chronically Ill Patients Assisted by Small Digital Bio-Pulse Sensors

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With the continuous increase of the ageing population, the number of patients with chronic diseases has increased dramatically. The limited medical resources and the strong demand for high-quality medical services are in stark contradiction. Active rehabilitation training is one of the most effective rehabilitation methods, but it is difficult to achieve through traditional medical equipment. In this paper, aiming at effective clinical rehabilitation, an in-depth study was carried out on the exercise intention recognition experiment of patients, hoping to provide an effective rehabilitation treatment method for the recovery of patients with lower extremity motor function injury. This paper introduces the detection principle of the photoelectric pulse sensor and the design scheme that is used in physical education. In the experiment, through the hardware connection, programming, and the development of the host computer software, the pulse signal of the human body can be presented stably on the computer. The monitoring of the pulse of the students can help the physical education teacher to understand the situation of the students and prevent accidents. In addition, we believe that the acquisition of students' pulse signals in physical education to build a database is of great significance for research and tracking of students' health status and the research results will certainly promote the development of pulse diagnosis. In order to make the lower extremity exoskeleton rehabilitation system that can be applied in clinical rehabilitation, according to the Brunnstrom staging of patients with central nervous system injury, the needs of patients in different stages in the rehabilitation process were analysed and active and passive lower extremity rehabilitation strategies were formulated. Aiming at the problem of real-time and accurate identification of human motion intention, and to alleviate the mechanism motion delay caused by the delay of mechanical and control systems in the human-machine integrated system, a differential sEMG real-time feature extraction algorithm is proposed. The results show that the sensor and monitoring system have excellent stability, and the auxiliary system can accurately reflect the changing trend of the human biological pulse, achieve the expected effect, and effectively assist in the monitoring of exercise data for patients with chronic diseases. After treatment, the joint range of motion and muscle strength basically returned to normal levels, and the patient was able to walk independently. Compared with traditional treatment methods, the recovery time is shorter, the recovery of muscle strength is more effective, and the medical staff is more relaxed.

1. Introduction

With the changes in social production and lifestyle, chronic noncommunicable diseases have gradually become a major threat to public health. Environmental pollution, the ageing population, and other factors have seriously aggravated the adverse trend of the prevalence of chronic diseases and thus brought about a series of social problems, such as the sharp rise in medical care costs, the insufficient number of working-age populations, the serious shortage of medical resources, and other serious threats to the sustainable development of the social economy. Therefore, it is an urgent task for economic and social stability and harmonious development to seek effective measures to curb the high incidence of noncommunicable diseases, improve the health of the public, and control the rapidly increasing social medical costs and economic burden [1]. The global healthcare industry is developing heavily and is gradually shifting from passive diagnosis and treatment of diseases to active health intervention and promotion. The related technology of health promotion theory coordinates the development of various stages of the health management process, develops cutting-edge testing equipment, develops advanced health maintenance technology, establishes professional health management talent team, and provides high-end and personalized tracking management services, supporting perfect medical health and commercial insurance. It has greatly driven the rapid development of health promotion and health and medical services, and thus simultaneously realized the improvement of the comprehensive health quality of the people and the effect of reducing the social and economic burden. With the rapid development of modern Internet and cloud computing technology, tracking and management of health promotion services by means of information technology have become a new trend in the development of the industry. In recent years, Microsoft, IBM, Apple, and other companies have gradually stepped into the health industry, and e-Health and other concepts have gradually become popular in the health and medical industry. Some enterprises have also launched many health detection devices and health information management software systems. Health promotion services still have serious fragmentation, low level of information, and intelligence. Each link of health promotion is separated from each other, and all kinds of equipment and system are difficult to efficiently connect. There are also many challenges in health records, data security, and patient privacy protection [2]. Therefore, the implementation of key technologies such as intelligent fitness service system, fitness service construction, overall solution, business degree of integrated health signs, parameter evaluation scheme generation, the fitness camp decision support, and online feedback of sports intervention plan guidance is expected to improve the efficiency of medical services and provide low-cost, personalized, and comprehensive health promotion services for people with chronic diseases and subhealth. The aim of health promotion service is to improve the health quality of the whole people, improve individual immunity and quality of life through scientific and reasonable physical activity plan, and, at the same time, achieve the purpose of preventing and controlling various chronic diseases.

With the development of science and technology, home monitoring equipment has become an indispensable tool for family self-diagnosis and treatment. Its main function is to diagnose physiological parameters and prevent and control diseases. Pulse and oxygen saturation parameters play a very important role in measuring physical health indicators [3]. An irregular heartbeat with low oxygen levels often causes us to feel dizzy, distracted, and anxious; in severe cases, it can cause fatal damage to the heart and even lead to heart failure, especially in vulnerable people such as the elderly. Therefore, monitoring pulse oxygen saturation not only plays an important role in our health but also can greatly reduce the incidence of cardiovascular and cerebrovascular diseases. In view of the high incidence of cardiovascular and cerebrovascular diseases, which are easy to relapse and difficult to cure, the prevention of the development of cardiovascular and cerebrovascular diseases has become a top priority. From the physiological indicators of the human body, pathological pulse baud signs as clinical diagnosis, and treatment to obtain information, this way has been the concern of the medical community. From the perspective of the development of science and technology, emerging the quick replacement of the development of the technology of electronic technology has been radiation to all aspects of daily life, brings challenges to other industries, and, at the same time, also brought the opportunity, and use of electronic communication technology and embedded technology, the combination of transformation and operating mode has become solve the uneven distribution of information resources and the main direction of resource scarcity. Especially in recent years, the arrival of the era of big data can effectively solve the problem of resource allocation if it is applied to medical engineering. In order to improve the accuracy of measuring human pulse, various pulse measuring instruments have been applied in medicine, thus opening a new medical diagnosis method [4]. With the rapid development of medical technology and related disciplines in medical institutions, medical monitoring engineering has become an indispensable part of the leading medical electronic equipment in China. The development of medical technology and science and technology goes hand in hand, and the development of modern medical technology plays a role of booster for the development of science and technology, and further increases the development of medical monitoring rooms. The use of new technology in medical monitoring equipment can continue to monitor the patient's condition and timely let the doctor understand the current patient's situation, so the portable home medical equipment and remote medical monitoring equipment are born from this. The Home Health Program is an innovative interdisciplinary technology that is the glue of modern products that combine electronics and medicine.

Based on health monitoring services, the aim of intelligent health promotion and personalized health service is achieved. Pulse detection is collected by a group of infrared sensors, one transmitting and the other receiving, using the principle of blood concentration changes when the heart beats. Infrared reception changes with the transmittance signal received by the beating of the heart. The operation is simple and convenient, relying on the portable medical remote monitoring terminal, and the results of the physiological parameters of the monitored will be monitored, stored and displayed in real time by mobile phone, and then sent to the health monitoring and management centre [5]. Doctors can observe the information of these parameters and make timely judgements on the health status of the monitored patients, which can be used to improve the treatment, prevention, and quality of life of the monitored patients. It can not only reduce the treatment cost and reduce the burden of patients, but also improve the treatment efficiency and save the treatment time of patients. Traditional pressure sensors are the most widely used, and their detection performance still has a lot of room for improvement. MEMS sensors are small and easy to integrate; flexible surface array acquisition information is more comprehensive, but the detection error is relatively large. In recent years, with the progress of sensing technology, the size of pulse sensor can reach millimetre level, which promotes the development of pulse diagnosis instruments from single point to multipoint, multichannel, and planar array and the development of pulse graph to three-dimensional direction. Different from traditional medical behaviours, the prevention and rehabilitation of diseases through exercise is a long-term behaviour, which is difficult to track and monitor, difficult to quantify indicators, and difficult to sustain large sample studies.

2. Related Work

There is a relative paucity of research on the health role of exercise itself. Although the importance of exercise to health has been recognized, statistics show that exercise can reduce the mortality of various diseases, so that the risk of cardiovascular disease, diabetes, and obesity is greatly reduced, but in-depth research, the actual effect of exercise lack scientific data support, also did not play its due role. The lack of medical research makes the system structure of sports health guidance relatively immature. Nanninga et al. elaborated on the analysis of the current environment of community fitness network, the role of mass fitness network, and service mode. Further analysis is made on the form of community fitness information content service, the factors affecting the public fitness information service in the community network environment, the public fitness information service mode based on the community network environment, and the application and effect analysis of sports intervention means in the network environment [6]. Zahid et al. performed intelligent human movement energy meter and nondrug intervention to exercise intervention as the core, in the process of intervention, to balance their diet movement management, performance management, and the individual quantitative management, using effective movement variable parameter monitoring energy integration objective data, safely and effectively guide the individual's movement. By comparing the changes of body weight, blood pressure, fasting blood glucose, and other indicators before and after exercise, it is proved that exercise is effective and feasible for rehabilitation [7].

With the development of digital signal processing technology, pulse oxygen saturation monitoring has become an indispensable instrument in clinical medicine. The research of pulse sensor and measurement technology has made great progress, but there are still many problems in the objectification of pulse diagnosis. Pulse signal contains extremely rich physiological and pathological information, and it is still not possible to use pulse waveform and TCM diagnosis to achieve clinical corresponding symptoms. In addition, different pulse sensors differ in principle, structure, and performance, resulting in inconsistent pulse waveform and measurement parameters, resulting in inconsistent pulse diagnostic criteria and lack of consistency in objectification indexes, and making it difficult to be widely applied in clinical practice [8]. Although various pulse sensors have greatly improved in accuracy and other performances, the detection principle is different from the traditional Chinese medicine pulse diagnosis principle, and it is still difficult to restore the real feeling under the finger of traditional Chinese medicine, especially the lack of information integrity such as multiple sites and multiple pressure gradients. It is meaningful and promising to match pulse map parameters with real pulse characteristics and related diseases and realize the objectification of pulse diagnosis. The new sensor is applied to pulse information sensing, optical fibre type, and low loss anti-electromagnetic interference; small size of MEMS chip is suitable for integration; and the microphone and ultrasonic type are noncontact, which can present the authenticity of pulse image to a large extent. A flexible surface array has good mechanical properties and large acquisition information. However, there are some problems such as immature technology development and difficult popularization, which still need further study. According to the sensing principle, pressure sensors are divided into piezoelectric, piezoresistive, capacitive, resonant, and piezomagnetic. At present, many types of pulse diagnosis instruments have been developed based on pressure sensors, and the technology research has been relatively mature. The basic principle of piezoelectric pressure sensor is the piezoelectric effect of dielectric. Liao et al. reported a pressure sensor based on edge field capacitance technology made entirely of biodegradable materials for real-time monitoring of arterial blood flow [9]. The sensor operates wirelessly through inductive coupling, providing negligible hysteresis, millisecond response time, and excellent cycle stability. Because the electrostatic attraction between the plates is very small, the action energy required is very small, the natural frequency is very high, and the dynamic response time is short, so the capacitive sensor is suitable for measuring dynamic and small pressure input. However, how to reduce parasitic capacitance and solve the problems such as nonlinear output characteristics and poor load capacity, and complex back-end measurement circuits has always been the focus of research. The principle of photoelectric volume sensor to detect pulse is that the blood vessel capacity changes with the pulse, causing the amount of haemoglobin in the blood vessel to absorb the light to change accordingly, and the pulse signal can be obtained by monitoring the light intensity. In the process of pulse signal acquisition, light reflection is generally adopted. Compared with other types of sensors, photoelectric sensors have the advantages of strong anti-interference ability, good signal stability, insulation, and immunity from electromagnetic interference. Zhang et al. realized the preparation of a large-area fabric-based pressure sensor array on a common fabric base through the fusion of Ni coating and carbon nanotube fabric assisted by a mask, which can realize the detection of pulse [10]. However, there are still many problems to be solved when using a flexible planar pulse sensor. Although the sensing principles are different, they all have their own advantages and disadvantages.

In recent years, scholars at home and abroad are devoted to the development of noninvasive and noncontact sensors. Such sensors usually measure human biochemical parameters indirectly on the body surface, which can automatically eliminate the instrument's own system error and high measurement accuracy. At present, pulse sensors are more and more widely used. From the initial realization of basic health monitoring, i.e., detection of human pulse signals, blood oxygen saturation, heart rate, systolic blood pressure, and other physiological signals, to the present day, wireless monitoring and portable wireless pulse monitoring can be realized. Pulse waveform analysis detected by pulse sensor can also be used to evaluate left ventricular ejection time, arterial wall stiffness, continuous cardiac output, etc. Winslow et al. pointed out that the rapid pulse wave technology could be used to explore the elastic function of adult carotid arteries, so as to study the progression of early atherosclerosis [11]. Krishnaswami et al. proposed a patch-based optical fibre pulse sensor, which is a wearable device composed of a sports wristband and the tip of an aluminium diaphragm optical fibre sensor with a diameter of only 1 cm. Coherent phase detection is used to improve the detection signal-to-noise ratio, restore high-fidelity pulse waveform, and have high sensitivity to weak acoustic signals [12]. Servati et al. proposed a fibre optic sensor based on Michael interference theory and explored its application in pulse and respiratory monitoring. Pulse measuring device based on Fibber Bragg Grating takes external bending curvature as abscissa and the relative light intensity corresponding to the central wavelength as abscissa [13]. The comprehensive sensing principle and application examples show that the optical fibre itself has the advantages of large capacity, low loss, small size, corrosion resistance, electrical insulation, electromagnetic interference resistance, and the small size of the sensing probe, no front-end amplification device. Compared with other methods of indirectly measuring blood pressure through the change of blood vessel volume, the optical fiber strain measurement principle based on the stress conduction of blood vessel wall fully considers the natural formation of blood vessels, which makes the measurement details of optical pulse sensor richer and has broad research prospects. Using the principle of acoustic detection to extract pulse signal is a noncontact pulse signal acquisition method. Dunn et al. proposed an electret capacitor microphone that could serve as a pulse sensor. Soft silicone rubber was used as a medium to enhance the mechanical coupling between ECM and the skin of the subject without affecting the signal source, and this method could measure the signal [14]. This method can effectively reduce the interference caused by incorrect measurement position and is wearable and suitable for long-term dynamic monitoring by detecting the infrasound generated by vibration caused by the tiny displacement of the surface skin during radial artery pulsation. It provides a new idea for pulse detection. Self-powered devices that can be directly attached to the surface of human skin have great potential for medical applications. They can realize the purpose of real-time continuous and accurate monitoring of human physiological signals without external power supply, which not only avoids the limitation of battery life but also solves the problems of energy supply and environmental pollution. Kim et al. made wearable medical devices by using the triboelectric pressure sensor based on the synergistic realization of the sensing function of the triboelectric and electrostatic induction effect, and effectively realized the real-time monitoring of pulse signals under the self-powered function [15]. The new sensor system, which is self-driven through integration, can be wearable and provides a new idea for portable and miniaturized pulse diagnosis equipment. However, as a new sensing system, how to achieve clinical promotion remains to be further studied.

3. Small Digital Biological Pulse Sensor-Assisted Health Monitoring System

3.1. Biological Pulse Sensor Acquisition Principle. The artery of abbreviation pulse refers to when the left ventricular diastolic blood of the body squeezes into the aorta, the blood vessels will stop the blood into the veins, at this time because of the blood into the aorta, so the aorta stress increase, forcing the aortic diameter expansion, in areas such as the human body, can be through the fingers and wrist to feel the pulse expansion phenomenon [16]. At the same time, the pulse is contracted by the heart's systolic function and the elasticity of the heart tube wall. When the ventricle opens, the arterial pressure will rise. When closed, the pressure of the artery is reduced, and this fluctuation of the artery produces pulse waves. There are many factors affecting the pulse wave velocity, mainly including arterial diameter and blood viscosity. The larger the arterial diameter is, the lower the pulse wave velocity will be; conversely, the smaller the arterial diameter is, the lower the pulse wave velocity will be.

The pulse waveform is mainly divided into ascending and descending branches. The reason of ascending branches is that the heart shoots blood rapidly and the pressure increases sharply when the heart contracts. Compared with the whole pulse cycle, the duration of ascending branches is shorter. The main reason for descending branches is when the heart slowly ejects blood, because the aortic valve is closed and the blood flows back to the aorta in the opposite direction, forming a repulse wave. At the same time, there was a small ascending waveform at the end of descending branch with a small amplitude, which was caused by the small amount of blood flowing into the vena cava during ventricular contraction [17]. The pulse wave can be obtained by pressure type and volume type. The working principle of the pressure pulse wave is to compare the pressure sensor to the human heart and convert the change of its pressure into the beating of the heart. Ignoring the pressure sensor and vessel wall thickness, the elasticity of the arterial wall allows pressure to be applied to the skin when the pressure sensor is attached. On the premise of not occluding blood vessels, arterial pressure and pressure on the pressure sensor show a certain relationship. Over time, the heart's beat is similar to the change in pressure, and the pulse waves are picked up by pressure sensors. Volume pulse wave is mainly the waveform obtained by converting blood vessel volume into light intensity change. When the blood flows through micro vessels through blood circulation, blood volume presents pulsation under the action of heart beating and changes from large to small through heart contraction. When the light source enters the human tissue, it will be absorbed by the tissue and attenuated, and will be absorbed by the photoelectric detector. In addition, the rhythm of blood vessels will promote the vasoconstriction, leading to periodic changes in the volume of internal blood, resulting in changes in the brightness absorbed by the blood. Finally, the pulse wave can be obtained by changing the light intensity. Volume pulse wave is mainly in the peripheral vascular arterioles, capillaries, and other micro vessels, so it contains a lot of circulatory physiological and pathological information, which can clearly reflect the internal blood circulation of the human body and is an important indicator to measure the body.

3.2. Framework of a Small Digital Biological Pulse Sensor-Assisted Health Monitoring System. According to the principle of biological pulse sensor acquisition, fusion detection terminal intelligent health, health management service network and mobile Internet, small digital biological auxiliary pulse sensor system designed by the terminal layer, core layer data and services, scientific fitness guidance network interactive layer, three layer network health monitoring management service platforms provide health signs parameter detection, exercise prescription release and management, fitness testing, health data tracking parameters, intelligent health management services, implementation of effective health promotion process, information comprehensive monitoring, objective and quantitative testing data, and automatic dynamic adjustment scheme of fitness, and scientific guidance for health promotion service [18]. The overall architecture of the small digital biological pulse sensor-assisted health monitoring system is shown in Figure 1.

The realization of health monitoring and promotion service is based on effective detection of users' basic health indicators and various physical indicators in the process of fitness exercise, and providing basis for rehabilitation guidance of patients with chronic diseases through real data sources. The terminal layer of the health monitoring and promotion service system integrates two categories of equipment and instruments, mainly including self-developed health sign evaluation equipment, intelligent fitness equipment and instruments, and provides system access interface to support third-party devices to connect with the system. The core layer consists of two parts: health knowledge base and health guidance service. The health knowledge base mainly provides storage and analysis of large sample health data, completes the storage and call of member users' physical signs information, and serves as the main basis for the generation of health guidance schemes. On this basis, the health knowledge base provides patients with basic knowledge of chronic disease, prevention, and treatment knowledge and life-style knowledge education, and guides patients to carry out self-monitoring and self-management of symptoms in daily life, so as to prevent, control, and delay the occurrence and development of diseases. The fitness guidance knowledge base, which is an important basic information source of prescription reasoning mechanism, gathers the main data sources and sample libraries for the generation of exercise prescription. The service coordinates the hardware and software of each intelligent service terminal in the system and manages the basic protocol configuration of various types of health equipment in a unified manner, including the information collection of individual Canon Kang, the promotion of resource access and integrated management, and the response and push mechanism of tracking service. Form a unified terminal interface specification and technical standard to complete the cross-network mechanism of information exchange and transmission of health monitoring services. Interaction layer is the main way to guide patients to promote the interaction of service system. It consists of two subsystems: fitness centre and mobile health assistant. Fitness guidance based on all kinds of health signs evaluation equipment, health evaluation methods, exercise and nutrition programme inference machine, personalized fitness, and nutrition programme are formulated for users, and users are guided to correctly execute on the intelligent fitness equipment.

3.3. Small Digital Biometric Pulse Sensor Auxiliary Hardware System. The design of the small digital biological pulse sensor auxiliary system is divided into the lower computer to collect pulse blood oxygen signal, the upper computer mainly displays waveform, and the App on the mobile phone mainly monitors the data in real time and gives alarm. Lower computer design is mainly through the sensor and its peripheral circuit for signal acquisition, the original pulse blood oxygen signal for amplification and filtering, and analog-to-digital conversion. Data are sent to the upper computer through the serial port, and the hardware circuit mainly includes sensor acquisition peripheral circuit, microcontroller hardware circuit, and Bluetooth module circuit [19]. The primary task of design is to select the sensor and microcontroller, and send the collected initial signal to the sensor's internal conditioning module for early amplification and filtering processing. Then, the analog output signal is converted from analog to digital, and the AD converted signal is sent to the controller through serial port. Bluetooth 4.0 communication mode is sent to PC and Android terminals. The software is used to store and play back the waveform on THE PC, and digital filtering is used to further remove some useless signal interference. Through printing, the real-time data of pulse blood oxygen waveform can be sent to the attending doctor or taken to the hospital for medical examination and monitor the patient's heart rate and blood oxygen in real time through the mobile terminal. If the blood oxygen value is lower than the normal value, the alarm will be made. Meanwhile, the blood oxygen value is slightly below the normal range. The programme structure of the sensor acquisition module is MAX30100, and the photoelectric detector is adopted. The red light can be driven by an internal timer to alternately illuminate the infrared. The photodetector converts the optical signal into electrical signal, the output signal is amplified and filtered, and the analog quantity is converted into digital quantity through the ADC.

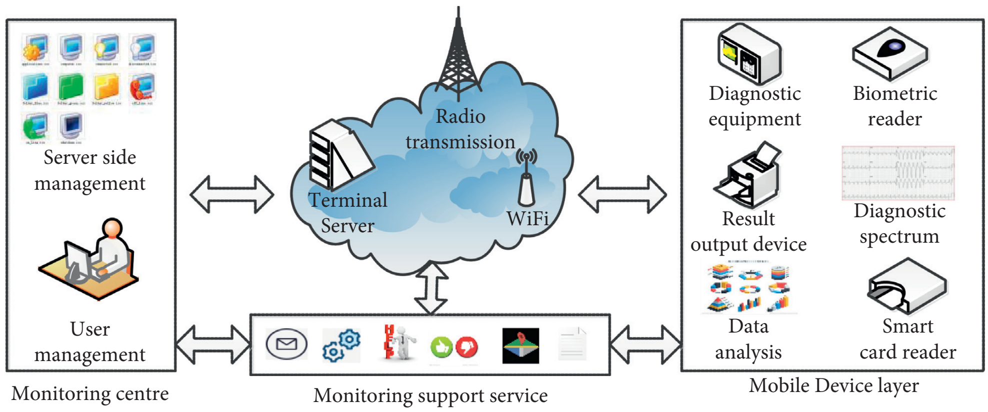

Figure 1: Overall architecture of a small digital biometric pulse sensor-assisted health monitoring system.

3.4. Software Framework of the Small Digital Biometric Pulse Sensor Auxiliary System. System software design is the main part of the whole monitoring system; software functions are mainly divided into UI interface design, pressure pulse data acquisition; and pressure pulse data analysis, and auxiliary functions are implemented, respectively. The structural framework of the software system is shown in Figure 2.

UI interface module mainly sets the basic functions of the system, patient information settings and serial port settings, and real-time pulse waveform drawing, which display pulse data values. The biological pulse data acquisition module receives the static pulse data and dynamic pulse data sent by hardware devices by developing communication protocols, and classifies the signals. The biological pulse data analysis module mainly carries out real-time signal processing, signal correction, and calculation of haemodynamic parameters for the received dynamic pulse data. The auxiliary function module mainly realizes data storage function record and collects pulse signal, and choose to save or play back the file; patient-related information generation; abnormal information prompt, real-time monitoring of physiological parameters, be careful when the output parameter exceeds the set alarm value and the system main interface prompt message.

Biological pulse data acquisition module is mainly responsible for receiving static pulse data and dynamic pulse data. The module task is to communicate with the machine, instrument host, and the software system through the form of a data frame transmission, can demand design data frame format, data frame and frame by frame head, and the data portion of the tail three parts: the frame head and tail frame contain some necessary control information, and data section contains a machine transmission of data [20]. Biological pulse data analysis module is mainly composed of dynamic pulse data analysis and static pulse data analysis. The module is responsible for the calculation of 10 parameters of hemodynamic and the value of pulse wave characteristic K, and the parameter results and pulse waveform are displayed on the main interface. The auxiliary function module is mainly composed of the original pulse data storage, patient information storage, and abnormal information prompt. The data storage function mainly completes the storage of pulse waveform. The storage method can be manual storage and timing storage. Manual storage is to manually intercept the pulse data of a certain period of time in the measurement process, which can obtain the data required for any period of time. Timing storage and pulse data are stored in text at a certain interval of programme running. The data storage is performed when abnormal signal is detected. After the data waveform storage thread detects this abnormal signal, the pulse data measured at the moment are stored locally in the form of text. By looking at these stored waveforms again, a more accurate assessment of a patient's health can be made.

3.5. App Design of the Small Digital Biometric Pulse Sensor Auxiliary System. The App design of the small digital biometric pulse sensor auxiliary system is mainly developed based on the Android system as software. Many smart phones use the Android system, which has a wide audience and has the advantage of open source. Therefore, the Android operating system is adopted in this App development. In terms of language preparation, the design mainly uses Java language for programming. In terms of system architecture, it is mainly divided into core layer, operation library layer, frame layer, and application layer. The framework is built from low to high. Its two main core layers are the application layer and the application framework. The application layer is composed of e-mail client, calendar, contacts, etc., written by the Java language. In terms of programme, Activity, Service, Content Provider, and Broadcast Receiver play a very important role in Android system. An activity acts as an interface in a thread, and all functions are performed on it. As the number of services increases, the interface will increase, and activities can jump between each other mainly through intents [21]. When jumping, you can pass values to each other, and when the new Activity replaces the old Activity, the old Activity stays on the stack, and when "Back" is clicked, the latter is replaced by the former. The Activity life cycle is shown in Figure 3.

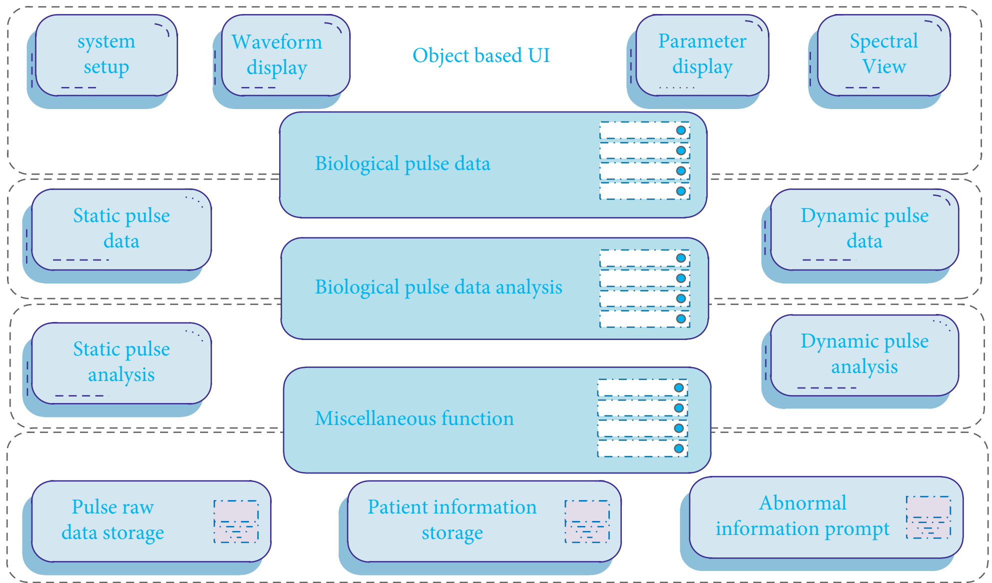

Figure 2: Small digital biometric pulse sensor auxiliary system software framework diagram.

A service cannot run by itself and must be attached to an Activity to run in the background. It can interact with other components, so services are often used in the creation process. Content providers are third-party data access methods. Data protection is critical in the Android system, so no application can access the application, but Android does not isolate all applications. Instead, the content provider is set up as a channel through which the application can access data in other ways. When the application shares data, the content provider class can be called and encapsulated as a Content Provider object. This allows for communication between different apps on Android phones. Broadcast is a mechanism for transmitting information between different applications. If you want to receive these broadcasts, you need to use Broadcast Receivers. App design does not access medical database and build cloud communication technology. In future studies, a large database should be established to integrate various medical data, and doctors can also be directly consulted and their own data synchronized to the medical database to achieve comprehensive and accurate monitoring.

3.6. Network Architecture for the Supporting Health Monitoring Systems. The Socket abstraction layer is a way for RT-Threads to access various network protocol stacks. It enables RT-Threads to support standard NETWORK sockets (BSD Socket API), various communication modules, and physical network cards. At the same time, RT-Threads have tailored and optimized SAL. Network transfers using SAL take up just 2.8 KB of ROM and 6.4 KB of RAM. The network architecture of the auxiliary health monitoring system is shown in Figure 4.

RT-Thread network framework consists of SAL socket abstraction layer, protocol stack layer, abstract device layer, and hardware layer. The protocol stack layer is composed of AT Socket, LwIP, Socket CAN, etc. The AT command of AT Socket adopts standard serial port to send and receive data, simplifying the complex communication mode. This enables network modules such as GPRS, 4G, WiFi, and NB-IoT to be easily ported to RT-Thread network architecture. LwIP is a protocol stack based on TCP/IP. Its code is open source and occupies less resources, so it is very suitable for network communication of embedded system. Meanwhile, RT-Thread can shorten space and optimize code on the basis of existing LwIP, making it more convenient to use in small embedded system.

4. Realization and Analysis of the Health Monitoring System Assisted by the Small Digital Biological Pulse Sensor

4.1. Assist Health Monitoring System Field Test. The test solution uses a wristband to fix the sensor on the wrist and connects the sensor with a signal processing circuit and a portable LCD to form a portable pulse monitoring system. The patient selected 2 patients with chronic diseases, mainly hypertension, from a hospital. They were initially selected as experimental subjects for a preliminary pulse test, and the test results are shown in Figure 5.

As can be seen from the figure, the pulse monitoring system can measure human pulse waveform in real time. The figure shows the pulse magnification of a single period in the pulse images of two subjects, respectively, which has the same graphic features as the standard pulse image. The figure above is basically consistent with the graphic features after the fusion of the main wave and the pulse front wave in the standard pulse image, which indicates that the pulse waveform measured by the pulse monitoring system is correct. After signal processing, the pulse signal shows clearly and satisfies the characteristics of the pulse graph, which varies from person to person. At the same time, each image is similar to the basic structure of the standard pulse

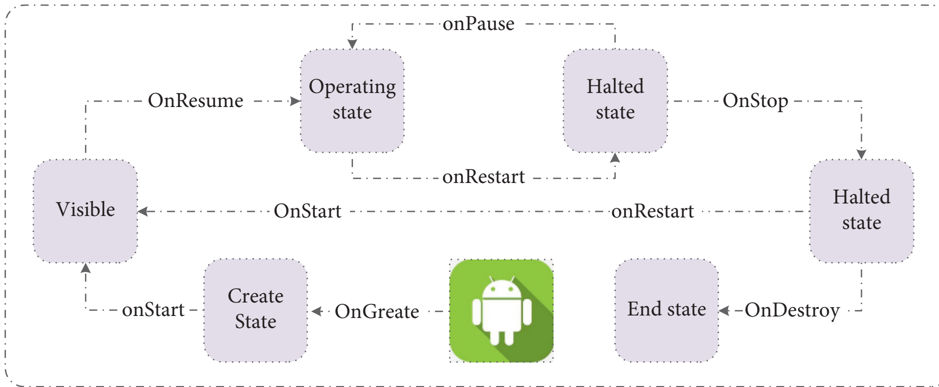

Figure 3: Activity life cycle diagram.

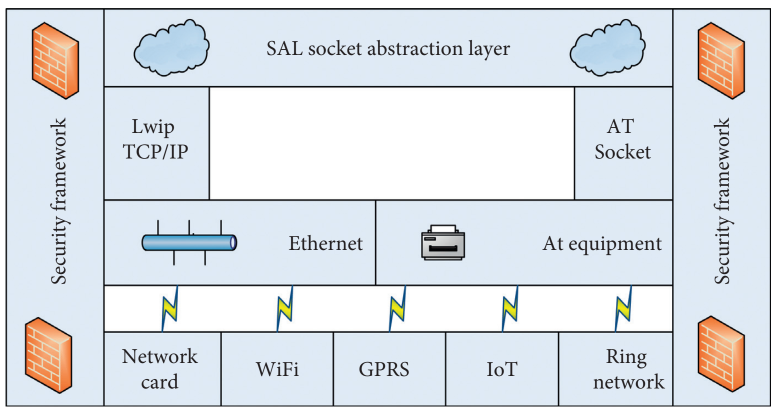

Figure 4: Diagram of the auxiliary health monitoring system network architecture.

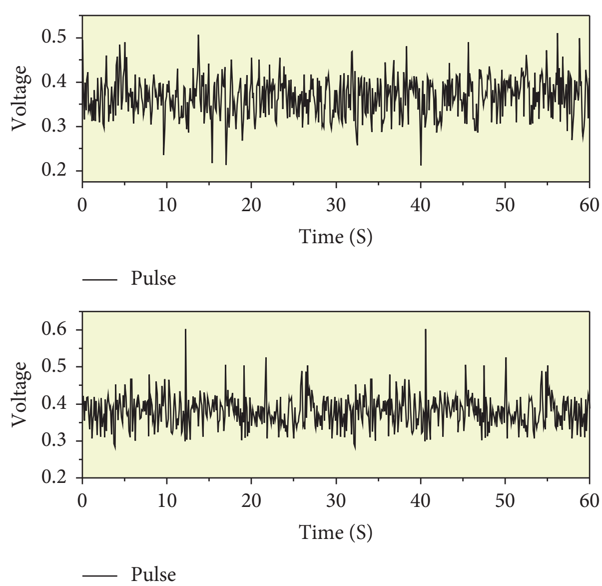

Figure 5: Graph of pulse test results.

graph, which shows that the measurement accuracy of the pulse sensor is very high, and the whole portable pulse monitoring system runs well. The peak fluctuation of the test graph is small and the waveform recurrence is high, indicating that the sensor and monitoring system have excellent stability.

4.2. Accuracy of Measurement of Output Parameters. The test uses mobile phones to test the programme. When receiving data, it first needs to be adapted to the Bluetooth module, configure the Bluetooth module, search the device, and click connect to detect receiving and receiving. When the sending and receiving data pass, then we click connect Bluetooth in APP for adaptation. If adaptation succeeds, real-time blood oxygen pulse data will be sent to the main interface. This paper mainly verifies the correctness of cardiac output parameter measurement, and randomly selects 50 groups of cardiac output data for calculation. Data analysis results show that there is a good correlation between the test data of the prototype and the theoretical data of the simulation experimental system, as shown in Figure 6.

The prototype test data and simulation experimental system data were taken out of 10 groups to calculate the relative error of cardiac output. The results showed that the maximum relative error was 10.44% and the minimum relative error was 5.44%. The experiment proved that the equipment had high accuracy, and the relative error result data are shown in Figure 7.

There is a certain error between the output of the prototype equipment and the data of the simulation system. The reason may be that during the acquisition process, the internal position of the sensor lamp deviates. Theoretically, bulb location forms a certain angle with the finger artery, and the angle of the experimental data is closer to the theoretical data. The design of the sensor has problems in sealing, and the external ambient light into the finger sleeve causes errors. In the process of controlling the piezoelectric valve, the prototype equipment could not accurately capture the time point of the artery pulse, resulting in the phenomenon of delay or advance, which affected the acquired data. The feasibility and accuracy of signal processing still need a lot of experiments to be corrected and optimized. The experimental device for simulating in vitro haemodynamics is not perfect and its accuracy needs to be improved, such as the temperature of water, the thickness of elastic hose, and the change of internal pressure. There are also great defects in the accuracy of installation and coordination, which directly lead to the great difference between experimental results and theoretical results.

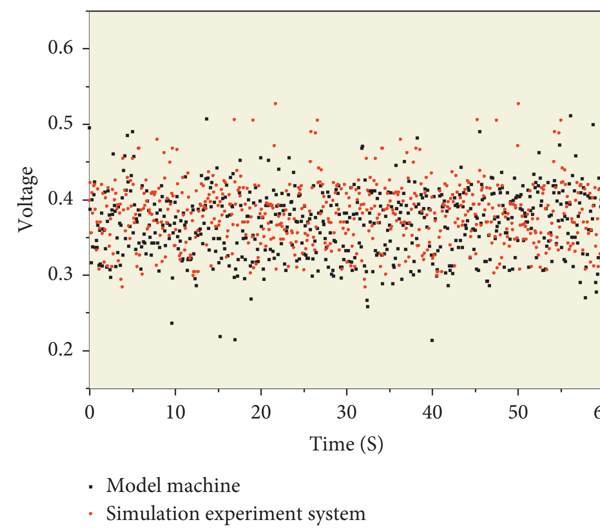

Figure 6: Test data of prototype and measurement results of the simulation experiment system.

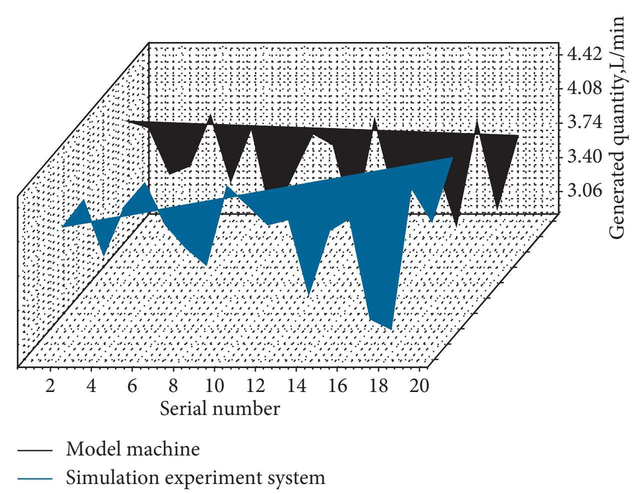

Figure 7: Statistical chart of relative error result data.

4.3. Evaluation of Rehabilitation Auxiliary Effect. Taking into account the age and physical condition of the subjects, tai chi, aerobics, and other aerobic programmes were selected first, combined with self-weight and dumbbell strength training, so as to achieve the combination of endurance and strength. The frequency of exercise was about 3 times a week. Exercise sessions are 15–25 minutes. For the implementation of the programme, mobile phone APPS and websites are used to track and manage the progress of fitness. During the 10-week experiment, the parameters of pulse health signs were tracked and detected. Make sure users do not smoke or drink alcohol or drink caffeine. During the measurement process, try to avoid external interference, such as adjusting the air conditioning to the appropriate temperature and reducing the environmental noise, so that the subjects can keep stable mood. Pay attention to the accuracy and repeatability of the test in the measurement, each index is tested twice, if there is a large deviation, re-test and check, until the test results are stable. The statistics of test results are shown in Figure 8.

You can see from the picture above. In carrying out scientific fitness guidance assisted sports health monitoring, the pulse index of the experimental group were changed, but the change of the control group was not obvious. The independent T-test method was used to test and analyse, and it was found that the decline of health monitoring indicators in the experimental group was significant. The t test results of these two indicators in the control group showed no significant difference. However, the average age of experimental subjects is older, indicating that in order to meet the requirements of normal blood, when the ambient temperature decreases, the blood flow speed of human body will slow down, increasing the demand of blood volume per unit time. By comparing the pulse changes of the experiment and

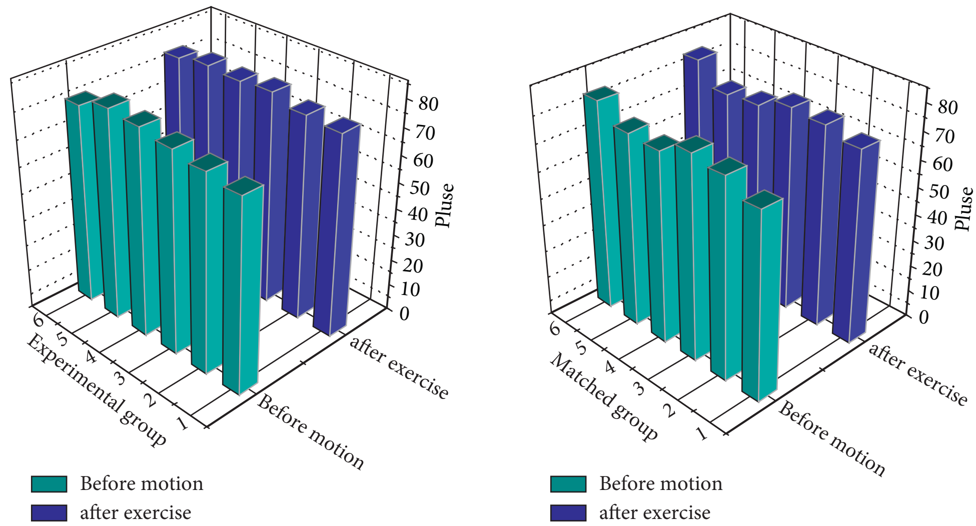

Figure 8: Graph of rehabilitation assistance test results.

the control group, it can be seen that health monitoring based on the health service system has obvious benefits for the pulse control of the subjects, which is conducive to the improvement of individual health status.

5. Conclusion

With the improvement of artificial intelligence computing ability and signal processing and analysis methods, the realization of physiological signal remote monitoring system will gradually become possible, and become the general trend of the development of medical field in the future. Exercise is closely related to and promotes the prevention and treatment of chronic diseases. Sports rehabilitation can not only guide the national fitness, promote scientific mass sports, and enhance the national physical fitness. It can also play a role in the prevention and treatment and rehabilitation of chronic diseases in various systems, directly affecting national health. Based on the pulse health monitoring of sports organisms, the software design mainly introduces the function division of software modules, including UI interface design, pressure pulse data acquisition, pressure pulse data analysis, and auxiliary functions of four modules, and the software system meets the functional requirements and can run normally. The signal is fed back to the embedded end of APP through the sensor. The simulation experiment system is designed, and the signal processing algorithm and hardware equipment are tested. A large number of simulation experiments show that the sensor and monitoring system have excellent stability, and the measurement accuracy of pulse sensor is high, the error is reduced, and the real-time performance is improved. However, the feasibility and accuracy of signal processing still need a lot of experiments to be corrected and optimized.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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