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Research Article

Networked Fitness Management System Based on Internet of Things

Haikun Wu [ID]

Teaching Department of Basic Course, Yinchuan University of Energy, Yinchuan 750100, China

Correspondence should be addressed to Haikun Wu; 160706226@stu.cuz.edu.cn

In recent years, with the rapid development of Internet of things and other technologies, the digitalization, networking, and intelligence of sports have become the current research focus. In this paper, the fitness management system based on the Internet of things is studied. By analyzing the system function and performance requirements, the design of fitness client (small tablet) of networked fitness management system is based on Internet of things. Receiving the fitness data uploaded by the fitness device through Bluetooth, the fitness data can be processed and displayed in real time with graphics. After the exercise, the fitness data can be uploaded to the central computer through Wi-Fi wireless. Taking barbell as an example, by analyzing the movement characteristics of barbell, Bluetooth MPU6050 module is used for data acquisition; the data collected includes angle, number, etc.; the relevant functions of barb-dumbbell movement are analyzed and designed; and the Bluetooth communication module and Wi-Fi communication module in the small tablet software system are designed and implemented. The relevant experiments were carried out based on the developed software and hardware platform. Recognition experiments on 7 classes of actions show that the proposed deep neural network learns well on small datasets, achieving an action recognition accuracy of 97.61%, and the SVM also achieves a recognition accuracy of more than 96%. In the 50 action cycle calculation experiments, the number statistics algorithm reached 100% calculation accuracy, and the action cycle calculation results are also close to the real value, proving the effectiveness of the periodic calculation method.

1. Introduction

Today, the times are constantly developing, and people's requirements for material life will gradually improve. While their living standards are met, they begin to pursue a healthy lifestyle, basically based on physical exercise? The Internet of things uses the network and various sensing devices to collect information and connect people, people and things, and things and things to achieve intelligent remote management and control. In the context of the current mobile Internet, the information acquisition technology is based on the Internet of things, as the fourth generation data acquisition technology, with its superiority and times, it will play an increasingly important role in the field of information technology. The intelligent sports health management system based on big data mining and Internet of things is composed of seven layers, namely, user layer, Internet of things layer, communication layer, network layer, function layer, rule layer, and data layer. Running is one of the important activities for people to conduct physical exercise. It is the most popular fitness activity in the world. It is highly evaluated in both the medical and sports circles, and it is also the most scientific and effective way to maintain a person's body and mind. The health management system designed based on Internet of things technology can provide remote monitoring and health guidance for patients, so as to promote personal health. Experimental results show that the system has achieved the expected effect.

(1) *User Layer*. The user layer is a collection of resident application interfaces, and users interact with the Internet of things layer and input or view personal

information through fitness APP, WeChat mini program, user interface of fitness equipment, and computer web page

(2) *Internet of Things Layer*. The IoT layer includes hardware such as wearable devices, phones or computers, smart fitness equipment, smart fitness venues, smart trails, virtual reality (VR), and augmented reality (AR) devices. In the hardware device, the interface program that interacts with the user and the calculation and storage model of fitness data is stored in advance, which can realize simple information query, evaluation, prediction, and other functions. The network layer is the Internet network, which complies with the international standard of network settings and information transmission, transmits the user information to the scheduled website, or transmits the information required by the user from the scheduled website to the user interface

(3) *Communication Layer*. The communication layer mainly includes 4G and 5G wireless networks. Through the wireless network, the user information is transmitted to the Internet or the Internet information is transmitted to the user

(4) *Function Layer*. Function layer is the core part of intelligent sports health management system. This layer obtains the fitness data to be calculated from the data layer and selects the appropriate operation rules from the rule layer to calculate the data, after the calculation results are obtained, the recommended information such as health status assessment information, sports injury and disease prediction information, and scientific fitness methods are pushed to the users through the network layer, communication layer, and Internet of things layer

(5) *Rule Layer*. Rule layer is the intelligent part of intelligent sports health system, including sports injury and disease evaluation model base, data mining method base, and scientific fitness knowledge base

(6) *Data Layer*. The data layer stores users' sports information, including personal basic sports database and personal sports status database

In the digital network era, people have higher requirements for sports and fitness; in the future, sports and fitness not only need good fitness equipment and environment but it also needs more convenient and intelligent health management, service guidance, social entertainment, and other refined fitness services. The innovation of sports and fitness equipment in digital network era will depend on the development of information technology and network technology. Using the Internet of things technology, it can connect residents, wearable devices, smart trails, smart fitness equipment, smart fitness venues, etc.; collect data for the intelligent sports and health management system; and push scientific fitness methods recommended by the system to

residents. IoT has unique advantages in fitness data collection and information output.

With the development of science and technology, at present, the integration and application of network technology in the field of physical fitness are one of the most important trends to promote the development of national fitness. At present, the portable equipment or large medical equipment used to monitor the basic parameters of the human body basically does not reflect the other value of, except for recording and monitoring. With the rapid development of embedded devices, wireless sensor networks, mobile computing, and other technologies, the public lives in an omnipresent network formed by the integration of communication networks, Internet, sensor networks, and so on. There is a growing body of research on how science, technology, and humanity can be combined, using new technologies and complex systems theory to digitize and dynamic humanistic knowledge, which is traditionally limited to language level and static.

Taking this as a starting point, a fitness client of networked fitness management system based on the Internet of things is designed. The related functions of health management system are analyzed and designed, and the Bluetooth communication module and Wi-Fi communication module in the small tablet software system are designed and implemented [1].

With the development of the times and the progress of society, the popularization of computer network technology and information technology in China is accelerating, and the Internet of things technology also appears in people's vision and gradually recognized by people. In this era of big data, it has brought huge challenges to all walks of life. Gao et al. put forward the method of applying the Internet of things technology to the research and development of data asset management system of graph database [2]. In order to monitor the classroom environment, control electrical equipment to reduce energy consumption, and analyze the classroom environment and utilization rate, Zhu et al. developed an intelligent classroom management system based on the Internet of things [3].

In the process of physical training, it is the key point of scientific physical training to adjust and control the strength of physical load in real time, accurately and effectively, and make it conform to the predetermined training plan. In view of the current problems in the field of sports and fitness, Shan and Mai designed and implemented a dynamic management technology of sports and fitness based on the concept of Internet of things and blockchain [4]. Li, based on the Internet of things (IoT), studied the method of using linear acceleration energy estimation model to evaluate athletes' special physical ability. A real-time monitoring platform for athlete training is designed [5]. Zhou's application management system of outdoor fitness equipment for all people based on big data of Internet of things will provide enough power for physical and social health of all people through intelligent terminals, Internet of things, and big data analysis [6]. Huang et al. designed an intelligent physical fitness monitoring system based on Internet of things technology [7] in view of the current demand for the popularization

FIGURE 1: Intelligent fitness management of the Internet of things.

of smart phones and athlete training monitoring. Yang and Paik studied fitness games based on the Internet of things [8]. He and Amp discussed the information visualization design of health management application in the digital information age. This paper analyzes the basic steps of visual information creation from four aspects: information acquisition, architecture, presentation, and interaction, and summarizes the visual design method and interface design method of sports information of fitness management APP [9]. Rekha et al. designed a Web application for fitness management system [10]. Dong et al. proposed a design scheme for a physical test management system, which was mainly developed by Python language, and Django framework was used as the Web framework [11].

On this basis, the fitness management system based on the Internet of things is studied. Through the system function and performance requirements analysis, the fitness client (small tablet) of the Internet of things based on network fitness management system is designed. Figure 1 shows the main functions of the intelligent fitness management system of the Internet of things [12].

2. Research Methods

It mainly designs and realizes the small tablet fitness system. At present, mobile phones, tablets, and other terminal products on the market basically provide Bluetooth function and Wi-Fi connection and communication function; the small tablet and central machine of the system are both tablets based on Android platform; in order to realize the seamless connection between small tablet and fitness equipment and central machine, considering the transmission distance and speed, the system uses Bluetooth and Wi-Fi wireless communication technologies to realize the system networking mode, that is, the fitness device communicates with the small tablet by connecting Bluetooth through the external serial port, the small tablet communicates with the central computer through Wi-Fi technology, and it makes full use of the built-in functions of the existing hardware devices and simplifies the networking mode of the whole system.

The small tablet mainly processes and stores the fitness data uploaded by the fitness device through Bluetooth wireless technology, real time graphic display is adopted, and the fitness users can view their fitness data at a glance, at the same time, according to the small board to evaluate the effect of exercise and remind fitness users to adjust the state of exercise, so as to achieve efficient and healthy physical fitness. The formula for Bluetooth wireless technology is shown in the following formula:

$$c = h\lambda. \tag{1}$$

The electromagnetic spectrum has a frequency range ranging from 1 to 10 at 25 times, ranging from thousands of meters to atomic size.

According to the formula provided by the Exercise Medicine Association is as follows:

$$Male : BMR = 13.7 * weight + 5.0 * height\text{-}6.8 * age + 66. \tag{2}$$

$$Female : BMR = 10 * weight + 6.25 * height\text{-}5 * age\text{-}161. \tag{3}$$

The data indicate that the basal metabolic rate in men is higher than that in women.

In normal life, the purpose of daily metabolism is to maintain the daily intake of calories, and the body weight will not increase or decrease based on the calorie intake. The formula of normal daily metabolism of human body is

$$TDEE = BMR * Factor. \tag{4}$$

In the design stage of the client, a small Android tablet of Rainbow brand i803Q1 is used, and it only provides real-time display of fitness graphics, so the small tablet hardware platform can meet the needs of the system.

Taking the bar dumbbell exercise as an example, the bar dumbbell exercise can be simplified to the fixed axis rotation of the forearm and upper arm by analyzing the characteristics of the bar dumbbell exercise; therefore, it is necessary to monitor the angle change of arm swing during the movement; and at the same time, it is necessary to collect the number of completed movements. Therefore, for the bar dumbbell movement, the fitness data to be collected include angle, number, start time, and duration. Before each fitness exercise, NFC certification must be carried out to ensure the security of fitness information, while providing identity information for the system to store fitness data. Through the demand analysis of the bar-dumbbell movement, its functional structure design is shown in Table 1.

Bar dumbbell itself cannot collect fitness data, the need for an external sensor to collect fitness data. Bluetooth MPU6050 module is used for data acquisition. The sensor is composed of Bluetooth HC-06 module and serial port MPU6050 module, data can be sent through Bluetooth, and each frame data sent is divided into acceleration packet, angular velocity packet, and angle packet. By detecting and analyzing the collected data, it can accurately obtain the current fitness status, and the detailed technical parameters of the wireless sensor module MPU6050 are shown in Table 2.

3. Result Analysis and Discussion

Taking the analysis and design of functions related to barbell movement as an example, the Bluetooth communication module and Wi-Fi communication module in the small tablet software system are designed.

3.1. Bar Dumbbell Movement Analysis. For so many kinds of bar dumbbell movement, how to distinguish the standard of action is particularly important in the process of action. Through simple calculation and analysis, the movement

Table 1: Movement function of bar dumbbell.

The serial number	Bar dumbbell movement function
1	The identity authentication
2	Bluetooth transmission
3	Real-time display
4	The number of statistics
5	Data is stored
6	Quality evaluation

Table 2: Technical parameters of the MPU6050.

Indicators	Parameter
Current	<10 mA
Appearance	15.24 mm∗15.24 mm∗2 mm
Voltage	3V ~6 V
Measure the dimensions	Acceleration: 3D, angular velocity: 3 D, attitude angle: 3 D
Range	Acceleration: 16 g, angular velocity: 2000°/s
Resolution	Acceleration: 6.1E-5 g; angular velocity: 7.6E-3°/s
The stability	Acceleration: 0.01 g, angular velocity: 0.05°/s
Baud rate	115200 kps/9600 kps

Table 3: Pendulum amplitude parameters of bar dumbbell movement.

The serial number	Action	Amplitude (°)	Maximum angular velocity (°/s)
1	Bending	135	135
2	Levelly obeying	90	90
3	Before resting	90	90
4	Bent arm	90	90
5	Bent over for bending	135	135
6	Elect	120	120
7	The bench press	90	90
8	The birds	90	90

amplitude of the bar dumbbell's typical movement is listed as shown in Table 3.

The amplitude of bar dumbbell movement is an important index to judge whether the movement is qualified. The amplitude comparison of 8 bar dumbbell actions is shown in Figure 2.

As can be seen from the figure, the maximum amplitude of bend lift and bend lift is 135°, and the maximum motion range is required. Push lift is 120°, and the rest of the movements are 90°.

3.2. Bar Dumbbell Movement Statistics and Frequency Analysis. The MPU6050 sensor is equipped with a Bluetooth chip, so during the exercise process, the sensor constantly collects the fitness data of the fitness user and transmits it to the small tablet through the Bluetooth chipr, and data
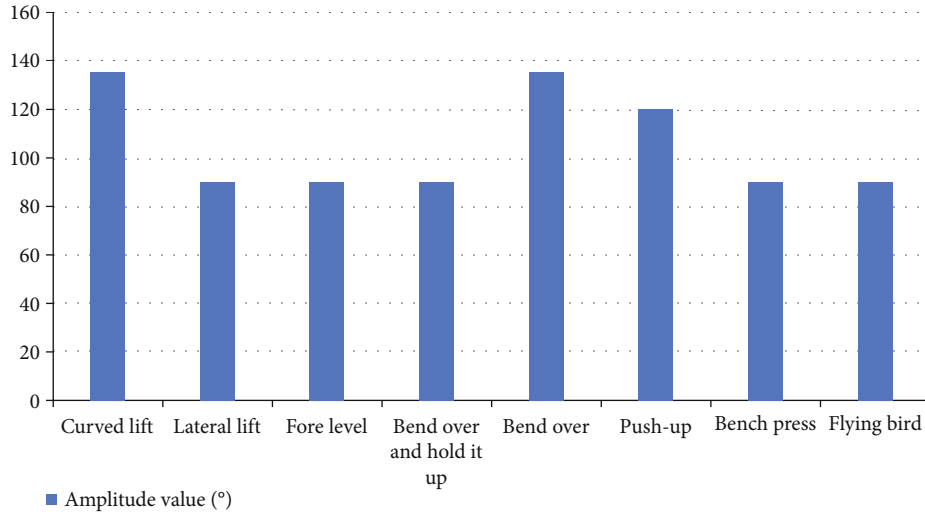
FIGURE 2: The amplitude of each bar dumbbell action.

TABLE 4: Data frame format of output angle of MPU6050 sensor.

Data number	The data content	Meaning
0	0×55	Baotou
1	0×53	Identify the package as an angle package
2	RollL	x-axis angle low byte
3	RollH	x-axis angle high byte
4	PithL	y-axis angle low byte
5	PithH	y-axis angle high byte
6	YawL	z-axis angle low byte
7	YawH	z-axis angle high byte
8	TL	Temperature low byte
9	TH	Temperature high byte
10	Sum	The checksum

frames transmitted mainly include three data packets of acceleration, angular acceleration, and swing angle of dumbbell motion. The frame structure of data is shown in Table 4.

The standard setting of the limit value and effective limit angle of X-axis detected by bar dumbbell movement types is shown in Table 5. Figure 3 shows the specific performance of the initial extremum and peak extremum of each action limit angle.

The limit angle and effective limit angle of bar dumbbell movement are mainly used for the statistics of the effective movement times of bar dumbbell movement, in the recognition of bar dumbbell movement, you have to define it by the y-axis angle, to realize the function of automatically recognizing the movement categories of barbell in the small tablet software, at the same time, the change of the angle of the Y-axis and the Z-axis should also be detected, but because the angle of the Z-axis is greatly offset, therefore, only according to the angle change of X-axis and Y-axis can we initially identify the same type of movement and count the number of movements. For example, in the bar dumbbell movement shown in the table above, the arm swing angle can only be

recognized as bar dumbbell bending when the initial angle is -90, and the peak angle is 45 degrees.

3.3. Bar Dumbbell Action Recognition. Action recognition adopts two modes of automatic recognition and key selection. In this system design, there are fewer sports to be automatically recognized, and the accuracy of automatic recognition is low due to the lack of z-axis positioning, the key selection mode is to carry out a specific movement, and the data of the movement is analyzed.

Through the analysis of the system function and performance requirements, the fitness client of the network fitness management system based on the Internet of things is designed. The width and speed of the IOT bandwidth are calculated as follows:

$$C = \frac{(L + S) = 6}{2} * 1.1, \tag{5}$$

$$\text{Bandwidth} = \frac{\text{speed}}{8}. \tag{6}$$

In order to realize the seamless connection between the small tablet computer and the fitness equipment and the central machine, considering the transmission distance and speed, the system adopts Bluetooth and Wi-Fi wireless communication technology to realize the system network mode.

In the automatic recognition mode, the effective angle of each movement is divided into five stages, when the motion angle changes in accordance with the corresponding five stages, then the type of movement can be determined and the number of effective movements completed can be counted. This method can eliminate some small fluctuation interference, but when there is unqualified action between two effective actions, it cannot be excluded. Otherwise, it will affect the research of fitness management system of Internet of things.

In order to operate the fitness management system conveniently and efficiently, create a bar dumbbell motion

TABLE 5: Parameter standard of dumbbell movement recognition.

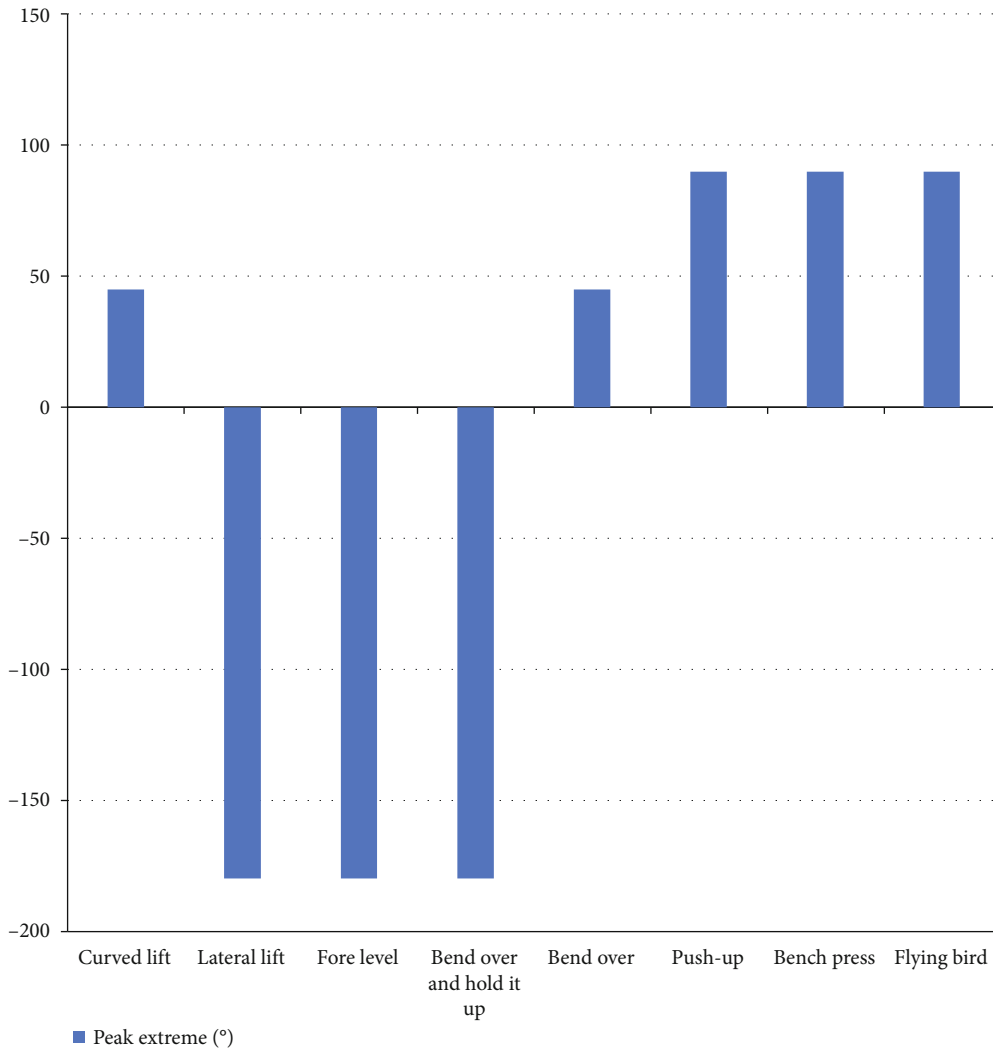| The serial number	Action	The limit angle		Effective limit angle	
		The initial extremum (°)	Peak extremum (°)	α_{min} (°)	α_{max} (°)
1	Bending	-90	45	-50	25
2	Levelly obeying	-90	-180	-160	-110
3	Before resting	-90	-180	-160	-110
4	Bent arm	-90	-180	-160	-110
5	Bent over for bending	-90	45	-45	25
6	Elect	-30	90	-10	70
7	The bench press	0	90	20	70
8	The birds	0	90	20	70

FIGURE 3: Limit values of X-axis angles detected by each movement type of bar dumbbell.

option list, as shown in Table 6. Set a different key number for each movement, and select the specified movement to exercise.

3.4. Design and Implementation of Bluetooth Communication Module. In the designed fitness management system, each fitness program must be equipped with a small tablet installed with the fitness App designed in this paper, and it is convenient for fitness users to watch the trend of fitness data and adjust exercise movements in real time. In order to reduce the trouble of wiring the fitness equipment, Bluetooth technology is adopted to realize the connection between the fitness equipment and the small tablet and upload of fitness data. Therefore, Bluetooth communication has become a bridge of

TABLE 6: Movement options of rigid dumbbell.

The serial number	Action options
1	Bending
2	Levelly obeying
3	Before resting
4	Bent arm
5	Bent over for bending
6	Elect
7	The bench press
8	The birds

Set the small tablet's Bluetooth device to be turned on by other software

Scan for bluetooth devices in the vicinity of the tablet

Select the desired bluetooth device for bluetooth matching

Real-time transmission of fitness date during exercise through bluetooth devices
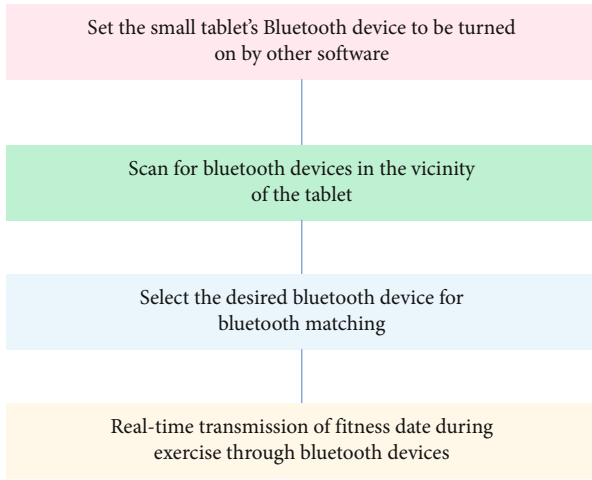
FIGURE 4: Four steps of Bluetooth communication program module.

data interaction between fitness equipment and small tablet; in this system, the Bluetooth communication program module is divided into the following four steps, as shown in Figure 4.

This system realizes the software program of Bluetooth communication by calling the built-in Bluetooth API of Android system. After launching the fitness App on a small tablet, the fitness software will automatically search for nearby Bluetooth devices and display them in a pop-up dialog box in the form of a list. Select the locked Bluetooth for connection. With the development of the Internet of things technology, wireless is the neural system of the Internet of things and also meets the needs of industrial production and material connection, and its transmission technology formula is as follows:

$$P = I * CPI * T. \tag{7}$$

Fitness application is convenient for fitness users to watch fitness data in real time. In order to reduce the trouble of fitness equipment wiring, Bluetooth technology is adopted to realize the connection between fitness equipment and small tablet computers. You can see that the aerobic heart rate during exercise is

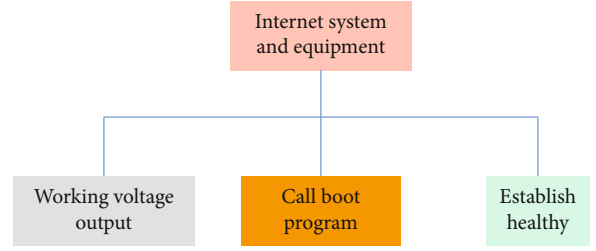$$RATE = (220\text{-age}) * (85\%\text{-}60\%). \tag{8}$$

Internet system and equipment

Working voltage output

Call boot program

Establish healthy

FIGURE 5: Connectivity of IoT devices.

Intelligent system design

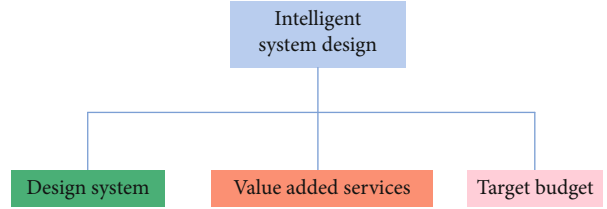Design system

Value added services

Target budget

FIGURE 6: Internet of things system setup.

3.5. Wi-Fi Communication Module Design. According to the initial system requirements and overall design, fitness data is transmitted between the small tablet and the central computer through Wi-Fi wireless communication technology. Similar to the operation mechanism of Bluetooth communication module, Wi-Fi communication technology also adopts Socket programming based on TCP/IP protocol. It works much like Bluetooth communication, by calling the bind function to bind the port between the small tablet and the central computer; under the C/S architecture, the small tablet software system can be used as the client and the central computer software system as the server, we register a listening event with the system by calling the listen function, if the information is dynamic, the port of the data processed by the TCP/IP system process is the same as the defined mapping, insert the message into the listen sequence of events, and wake up the receiving process to receive the message, as shown in Figures 5 and 6.

4. Conclusions

This paper mainly studies the fitness management system based on the Internet of things. From the point of view of the fitness person, it does not bring the best fitness effect to the fitness person. Through the system function and performance requirements analysis, based on the internet of things network fitness management system fitness client (small tablet) design, the fitness data uploaded by the fitness equipment can be received through Bluetooth, and the fitness data can be processed and displayed in real time with graphics, after the exercise, the fitness data can be uploaded to the central computer through Wi-Fi. Taking barbell as an example, by analyzing the movement characteristics of barbell, Bluetooth MPU6050 module is used for data collection, including angle and number. The relevant functions of bar dumbbell movement are analyzed and designed, and the Bluetooth communication module and Wi-Fi communication module in the small tablet software system are designed

to realize the communication and data processing of the small tablet. Achieving an action recognition accuracy of 97.61%, the SVM also achieves a recognition accuracy of more than 96%. In the 50 action cycle calculation experiments, the number statistics algorithm reached 100% calculation accuracy, and the action cycle calculation results are also close to the real value, proving the effectiveness of the periodic calculation method. There are many health and exercise parameters, and only two of them are selected in this paper to realize the basic prototype system. In the next step, a variety of health data and exercise data can be added to obtain multiple health parameters and exercise parameters, so as to provide more detailed data analysis for people's fitness and improve their fitness effects.

In the process of research, there are still the following parts to be improved: (1) the system adopts the single sensor collection of limb movement data, this way is more convenient to use, but can only be used for a single limb movement, and follow-up research can install multiple sensors and multiple sensors of data fusion, to realize the identification of complex limb movements. (2) Limited to the experimental conditions, the number of training data sources is small. In addition, the experiment uses the computer in the LAN to replace the cloud server. In subsequent studies, the number of subjects can be increased and the number of remote servers runs by processing system software.

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 there are no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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