Design of Real Information Collection Model of Physical Fitness for the Elderly Based on Internet of Things Technology

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Abstract. In order to optimize the efficiency of traditional physical information collection, this research designed a physical fitness information collection model for the elderly based on the Internet of Things technology. In the Internet of Things environment, select the collection node and install sensor equipment, and use the Internet of Things technology to drive the collection program. From the three aspects of human body structure, physical fitness health parameters and fitness action posture, the collection content of physical fitness information for the elderly is determined. Then call the sensor equipment, with the support of the Internet of Things technology, through the analog-to-digital conversion and filter storage to obtain the real-state information collection results. Through comparison with traditional collection methods, it is found that the collection accuracy of the model in this paper is higher and the collection time required is shorter, so the collection efficiency of the model in this paper has been effectively improved.

Keywords: Internet of Things technology · Sports fitness · Real state information · Information collection · Sensor equipment

1 Introduction

Physical fitness highlights the physical exercise as the main means of attention to people's physical growth and development and physical development. Through the selection and study of fitness and sports, we can cultivate people's sports fitness hobbies and sports expertise, so as to obtain scientific fitness methods, develop a civilized and healthy lifestyle, and make people have the adaptability to adhere to physical fitness in different environments. The most important role of physical exercise is to improve people's health in an all-round way. The specific performance is as follows: prevent cardiovascular disease, improve the function of respiratory system, improve the function of digestive system, reduce the risk of diabetes and prevent bone fracture. With the promotion of national fitness fever, the audience group of sports fitness is gradually expanding, and the elderly also join the ranks of sports fitness.

Unlike young people, the physique and body organs of the elderly are gradually failing, and the exercise intensity they can withstand is limited to a certain extent. In

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order to avoid a series of physical problems caused by improper exercise or excessive exercise intensity for the elderly during physical fitness exercise, it is necessary to use high-tech means to collect and monitor physical fitness information.

Data acquisition refers to the automatic acquisition of non electric quantity or electric quantity signal from analog and digital units to be tested, such as sensors and other devices to be tested, and then sent to the upper computer for analysis and processing. Most of the collected data are instantaneous values, that is, a characteristic value in a certain period of time.

According to the relevant research results at home and abroad, the typical data acquisition methods include metadata based data acquisition method, compressed sensing based data acquisition method and LabVIEW based data acquisition method [1, 2]. However, there is a problem of low collection efficiency when the traditional information collection methods are applied to the real state information collection of the elderly sports fitness. Therefore, based on the traditional methods, this paper applies the Internet of things technology.

The Internet of Things technology is the third revolution in the information technology industry. The Internet of Things refers to the connection of any object to the network through information sensing equipment according to an agreed protocol, and the object exchanges and communicates through information media to realize intelligent identification, positioning, tracking, supervision and other functions. There are two key technologies in IoT applications, namely sensor technology and embedded technology. In this study, the Internet of things technology is applied to the elderly sports fitness real information collection, to provide hardware equipment and technical support for data collection, in order to improve the efficiency of elderly sports fitness real information collection. The experimental verification shows that the acquisition model designed in this study has higher accuracy and shorter acquisition time, which fully proves that the model has higher application advantages.

2 Design of Information Collection Model of Physical Fitness for the Elderly

First select the appropriate development technology based on the understanding of the model design principles, then clarify the functions of the entire system, and finally determine the overall process plan of the system. The physical fitness information collection model for the elderly should follow the principles of reliability, advancement, operability and maintenance, integrity and openness [3]. Under the above-mentioned design principles, the design and development of the model are realized from multiple aspects such as signal sensing, analog-to-digital conversion and data processing. The sequence diagram of the data acquisition program is shown in Fig. 1.

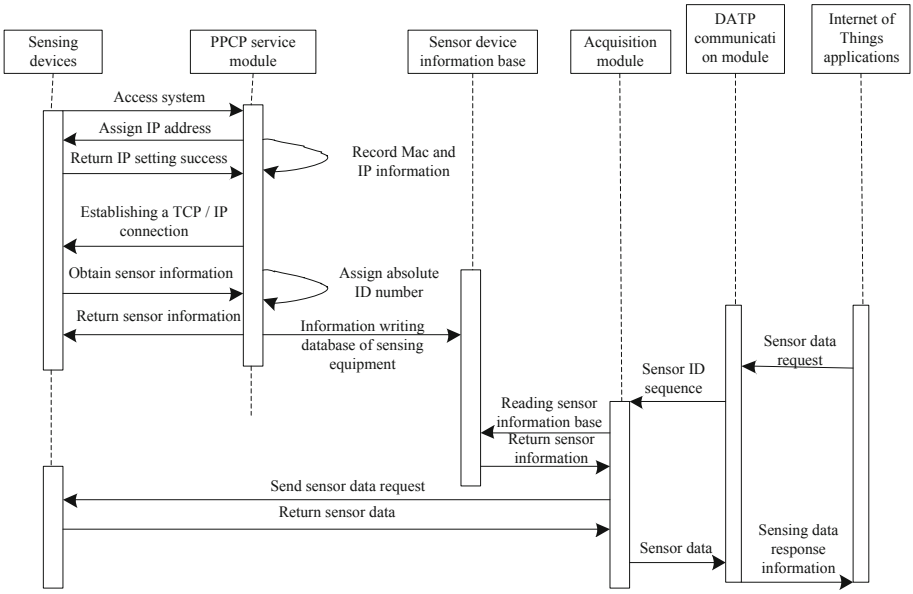

Fig. 1. Sequence diagram of information acquisition program

2.1 Build an IoT Network Environment

Internet of things is a network based on the Internet, traditional telecommunication network and other information carriers, which enables all the ordinary objects that can perform independent functions to realize interconnection and interworking. According to the location of each measurement point in the Internet of things, the structure of IOT network can be divided into three topologies: star, tree and net. The specific results are shown in Fig. 2.

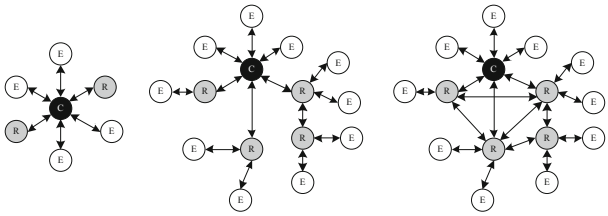

Fig. 2. Topological structure diagram of IoT network

In Fig. 2, C is the coordinator, R is the router, and E is the terminal device. As can be seen from Fig. 2, the star structure is a single hop network composed of a coordinator and multiple terminal devices. There is only communication between the coordinator and each terminal device, and the communication between each terminal device is forwarded by the coordinator. The tree structure is composed of a coordinator and multiple star structures. In addition to point-to-point direct communication between

devices and parent or child nodes, other devices can only complete message transmission through tree routing [4]. However, the mesh structure is based on tree network. The difference is that the network structure allows all nodes with routing function to be directly interconnected. The routing table in the router cooperates to realize the network routing of messages, which reduces the message delay at the cost of more storage space and enhances the reliability.

2.2 Install Real Information Collection Equipment

Before installing the real-state information acquisition equipment, it is necessary to determine the basic content of the real-state information collection and select the installation node of the collection device. The movement of human body comes from the movement of bones, so the two-dimensional stick human body model is selected to build the human body structure. A total of 13 line segments and 15 joint points are used to represent these features. The names of the marked points are shown in Fig. 3.

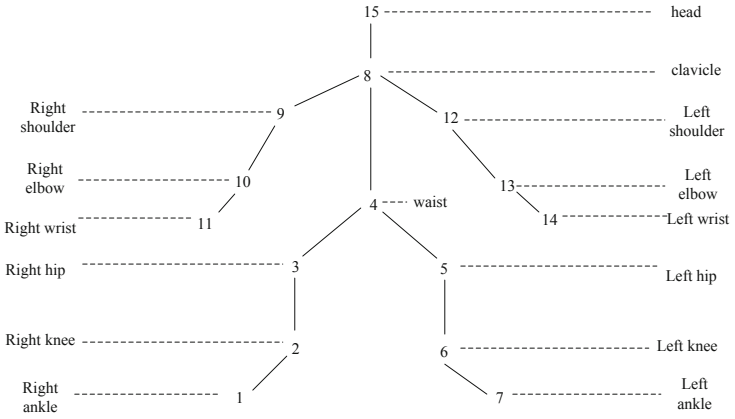

Fig. 3. Two-dimensional stick-shaped human body structure diagram

Location of the marking points corresponding to the human body is shown in Fig. 4.

Through the data characteristics of each human body structure sports fitness movement, determine the type of corresponding node installation acquisition equipment and the corresponding data collection content [5]. Through the analysis, it is found that the acquisition equipment to be installed includes acceleration collector, temperature collector, pressure collector, health data collector, etc. The overall design of acquisition node is shown in Fig. 5.

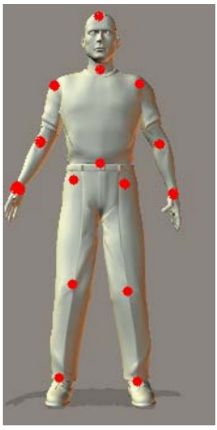

Fig. 4. Human position map corresponding to the installation node of the acquisition device

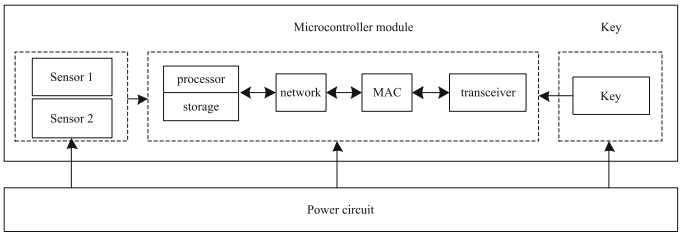

Fig. 5. Block diagram of acquisition node design

In Fig. 5, the sensor module consists of sensor and peripheral circuit. The sensor collects analog signal and converts it into digital signal through on-chip A/D conversion circuit, and the single-chip microcomputer can read the data. The microcontroller module reads the data and sends it out by radio frequency, using the protocol specifications of application layer, MAC layer, network layer and physical layer, and the data is transmitted in the specified format; the key is mainly responsible for function selection; the power supply circuit supplies power to the node.

Design a three-axis acceleration sensor circuit, as shown in Fig. 6.

Since the selected chips belong to the same series of products, the chip packaging and peripheral circuits can be used in common. As an analog acceleration sensor, the voltage signals of the three axes output in the circuit need to be filtered by capacitors C16, C18, C19 and then input to the MCU AD conversion module. The ACC_X output from pin 12 is connected to the AD of the MCU STM32. The PC0 pin of the conversion module, the ACC_YY output from pin 10 is connected to the PC1 pin of the MCU, and the ACC_Z output from the pin 8 is connected to the PC2 pin of the MCU. The reference voltage of the AD conversion module of MCUSTM32 is the regulated voltage of 3.3 V [6]. The capacitor C10 in the circuit is a de-pro-capacitor, and its function is to ensure the stability of the chip's supply voltage.

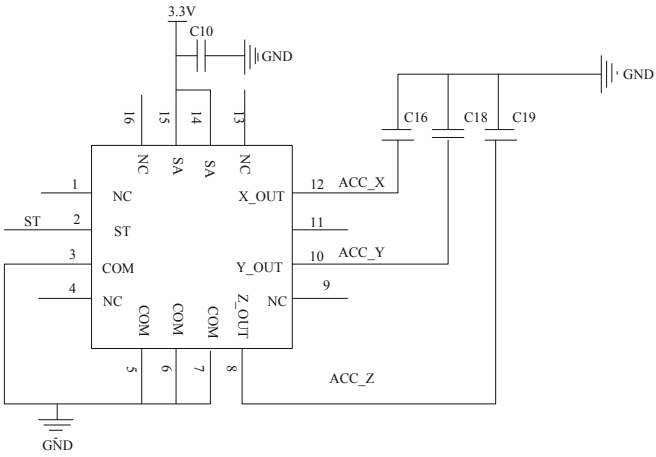

Fig. 6. Circuit diagram of acceleration sensor

The temperature sensor uses infrared temperature measurement technology. Due to the movement of charged particles, all objects whose temperature is higher than absolute zero continuously emit infrared radiation energy to the surrounding space. The energy wavelength is mainly concentrated in the 0.6–15 um band. The relationship between the radiation energy density and temperature is in accordance with Stephen Boltzmann radiation law

$$E = \varepsilon \sigma T^2 \tag{1}$$

In the formula, E is the total radiant energy of an object with a temperature of T, σ is the Stephen Boltzmann constant, and ε is the emissivity. As long as the temperature and emissivity of the object are known, the radiant power emitted by it can be calculated. Conversely, if the radiant power of the object is measured, the temperature of the object can be determined. The output signal of the infrared sensor is the result of the combined effect of the measured target temperature T_o and the sensor's own temperature T_a:

$$V_{ir}(T_a, T_o) = A(T_o - T_a) \tag{2}$$

Where the unit of temperature is Kelvin and A is the instrument constant, which is related to the design structure of the sensor. In the same way, the operation principle and structure of other sensors can be designed.

2.3 Use IoT Technology to Drive the Acquisition Program

When the sensor equipment is installed, the microcontroller is used to realize the call control of multiple sensors and the driving of acquisition program. Microcontroller is the core of acquisition node and collection node, which is responsible for sensor parameter configuration, protocol program initialization, operation, data reading and sending [7]. In the collection node, it is responsible for the initialization and operation of protocol

program, the establishment and binding of network, and the reception of data. The received data is processed and sent to PC serial port debugging software through serial port. The connection between the sensor and the microcontroller structure is shown in Table 1.

Table 1. Comparison table of acquisition sensor and microcontroller interface

Sensor number	Name of external sensor and power supply	Microcontroller pin
1	BUTTON1	P0.1
2	ADXL_MISO	P0.2
3	ADXL_MOSI	P0.3
4	ADXL_CSN	P0.4
5	ADXL_SCLK	P0.5
6	INT1	P0.6
7	TMP_DATA	P0.7
8	INT2	P2.0
9	LED1	P1.0
10	LED2	P1.1
11	TMP_SCK	P1.2
12	TMP_CS	P1.3
13	DEBUG_CSN	P1.4
14	DEBUG_SCLK	P1.5
15	DEBUG_MOSI	P1.6
16	DEBUG_MISO	P1.7
17	DEBUG_DD	P2.1
18	DEBUG_DC	P2.2
19	RESET	RESET_N

2.4 Determine the Content of Physical Fitness Information Collection for the Elderly

2.4.1 Body Structure Information

Human motion analysis pays attention to the kinematics and dynamics information of the human joints, and has no requirements for the appearance of the human body. Therefore, a simple and efficient bone model can meet the needs. The human body can be divided into 14 parts: head, left upper arm, left forearm, left hand, right upper arm, right forearm, right hand, torso, left thigh, left calf, left foot, right thigh, right calf and right foot. Each part of the human body can be regarded as a rigid body, and each rigid body is connected

by joint points. According to the position of the connection point, it can be divided into 14 joints: neck, left wrist, left elbow, left shoulder, right wrist, right elbow, right shoulder, waist, left Marrow, left knee, left heel, right marrow, right knee and right knee joints. The most basic movement of each joint is the rotational movement around the x, y and z axes, which are called rolling, pitching and yaw, respectively. There are 34 degrees of freedom in rotation. In order to simplify the motion of human joints, the following conventions are made for the motion analysis of each joint: the rotation of the ankle joint in three directions only analyzes the pitch motion; the hip joint and the shoulder joint have three degrees of freedom, but these two joints are biased during walking and running. The pendulum direction movement is small, so only the rolling and pitching movement is analyzed; the rotation movement of the wrist joint is not analyzed [8]. However, due to differences in genes and growth environments, there will be subtle differences in human body structure. Therefore, in the process of human body data collection, specific collections are mainly based on the size of each joint and the length of bones.

2.4.2 Sports Fitness Health Information

The physical health information of the elderly includes body temperature information, pulse information, heart rate information, blood oxygen information, ECG information and blood pressure information. The temperature information is mainly collected from the temperature sensor to read and convert the data. The conversion formula between the read-out data and the temperature information is as follows:

$$T = (\text{Data H: Data L}) \times 0.02 \times 273.15 \tag{3}$$

In the formula (3), Data H: Data L is the result of the read data. Pulse is the arterial pulse. In each cardiac cycle, the cyclic expansion and return of arterial vessels due to the alternation of ventricular contraction and relaxation is called pulse, and pulse is the fluctuation caused by heart contraction, so under normal circumstances, the pulse is exactly the same as the heart rate. A typical pulse waveform is shown in Fig. 7.

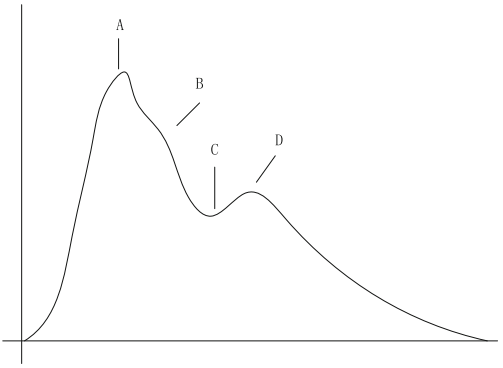

Fig. 7. Typical pulse waveform

In Fig. 7, a, B, C and d represent the main wave, tidal wave, and the trough and peak of the heavy pulse respectively, which constitute a pulse wave period. The photoelectric

sensor is based on Lambert Beer law. According to Lambert Beer law, when a beam of monochromatic light passes through a uniform non scattering light absorbing material vertically, the absorptivity of the absorbing material for a certain monochromatic light is directly proportional to its concentration. The formula of this relationship is expressed as follows:

$$\mathrm{I} = \mathrm{I}_0 e^{-\mu CL} \tag{4}$$

In the formula (4), I and I_0 are the intensity of the emitted light and the incident light respectively, μ is the light absorption coefficient of the medium, C is the solution concentration, and L is the optical path length. Reading the reading in the photoelectric sensor can get the result of the pulse data collection during the physical exercise of the elderly. In addition, the heart rate information is collected using the electrocardiogram method, which extracts the heart rate from the electrocardiogram signal.

In order to measure ECG signal, it is necessary to place signal electrodes and reference electrodes at different positions on the human body surface, which are usually placed on both sides of the chest, left and right hand or hands and feet. The electrode is connected with the positive and negative electrodes of the electrocardiograph through the lead wire, and the heart rate value is obtained from the lead ECG. In the same way, we can get the results of sports fitness health information collection according to the corresponding sensor equipment.

2.4.3 Sports Fitness Action Posture Information

According to the guide electrode and placement position used in the measurement, the detected EMG signal can be divided into needle electrode EMG signal and surface electrode EMG signal. The former uses needle electrode as the guide electrode and inserts it into the muscle., The potential information detected directly in the vicinity of the active muscle fiber, the latter is based on the surface electrode as the guiding electrode, and the electrical activity of the muscle measured when it is placed on the skin surface is integrated on the detection surface [9]. Using IoT sensor equipment combined with the muscle power of the elderly in the physical fitness process, the electrical signals of each joint, sole and skin are obtained, and the current physical fitness strength and posture are analyzed.

2.4.4 Analog Signal Conversion

The process of analog-to-digital conversion is the process of analog signal acquisition, which includes three basic steps: sampling, quantization and coding. The sample data set is composed of continuous analog signals in time according to a certain time interval, and it is transformed into discrete signals in time angle. This process is called signal sampling. The value of the continuous signal at any time is known, but after sampling, in addition to the value of the sampling time, other signals are lost. The larger the sampling period, the more serious the loss of information. Therefore, in actual data collection, a certain sampling frequency must be guaranteed [10]. Quantization is a process of approximating analog quantities with finite word length digital quantities, that is, the process of digitizing analog quantities. Encoding is to convert the quantized number into

binary digits for the computer to receive and process. After the three-step conversion, the analog signal becomes a digital signal that is discrete in time and quantized in amplitude. These three steps are all done by the A/D converter. Figure 8 is a schematic diagram of signal analog-to-digital conversion.

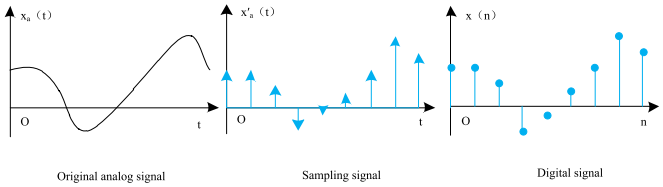

Fig. 8. Schematic diagram of analog to digital signal conversion

2.5 Real-State Information Collection, Transmission and Filtering Storage

The physical fitness information data of the elderly collected by the sensor device is uploaded using the Internet of things technology. When uploading, the MAC address of the device is carried. After receiving the data, first judge whether the main switch of the data point storage state of the device is on according to the MAC address of the device. If it is, the value of each key in a frame of JSON data is extracted, Determine whether its storage state is true. If it is true, continue to judge whether the data type of the data is the same as that stored in the database. Only when the above three conditions are met can the data be stored.

3 Comparative Experiment Analysis

Based on the Internet of things technology, the real-time information collection model of the elderly sports fitness is established. Through the steps of establishing ZigBee network, collecting and analyzing the sensor measurement data, the data is finally sent to the computer through the serial port to display, which can make the user conveniently observe in real time. In this process, we should set up serial assistant, connect sensor and acquisition board, host computer coordinator and PC. PC can output the address of terminal node, collected temperature, pulse, acceleration information and analyze the result through serial port.

Figure 9 shows the actual collection results of sports fitness acceleration information for the elderly under this model.

A total of 10 elderly people were selected as the research objects in the experiment. The same test object was measured five times, and the average value was obtained as the information collection result of the object. In order to form an experimental contrast. Using professional data measurement equipment to measure the real-time sports data of physical fitness, and taking it as the control standard of the collection results. In addition, the traditional information collection method is also set as the comparison method in

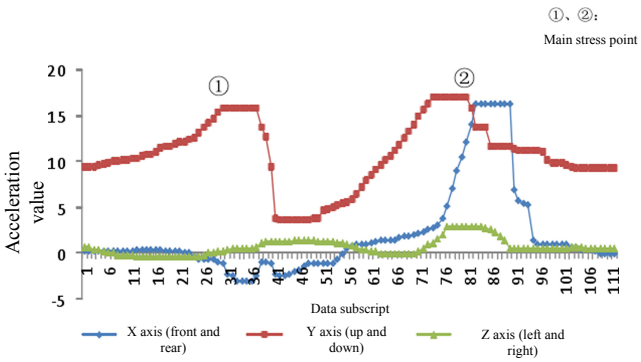

Fig. 9. Real state acquisition results of acceleration information of sports fitness

the experiment. After the operation of the collection model and the comparison with the standard data, the test and comparison results about the collection accuracy are shown in Table 2.

Table 2. Comparison results of acquisition accuracy test

Sample number		1	2	3	4	5
Standard data	Temperature (K)	35.9	35.8	35.2	36.1	35.9
	Pulse (beats/min)	120	111	116	108	112
	Acceleration (m^2/s)	16	22	14	21	17
Traditional models collect data	Temperature (K)	35.6	35.7	35.1	35.9	35.7
	Pulse (beats/min)	118	109	114	106	111
	Acceleration (m^2/s)	15	19	13	18	16
Data acquisition of the model in this paper	Temperature (K)	35.9	35.8	35.2	36.0	35.9
	Pulse (beats/min)	120	110	115	108	112
	Acceleration (m^2/s)	16	21	15	21	17
Sample number		6	7	8	9	10
Standard data	Temperature (K)	36.3	36.5	36.0	36.1	36.6
	Pulse (beats/min)	117	121	115	105	113
	Acceleration (m^2/s)	19	21	20	16	19
Traditional models collect data	Temperature (K)	35.9	36.1	35.5	35.8	36.2
	Pulse (beats/min)	120	118	117	101	110
	Acceleration (m^2/s)	17	19	21	14	16
Data acquisition of the model in this paper	Temperature (K)	36.3	36.5	36.0	36.1	36.6
	Pulse (beats/min)	116	120	115	105	113
	Acceleration (m^2/s)	19	21	19	16	18

It can be seen from the data in Table 2 that the data collection results obtained by the model in this paper are closer to the standard data, that is, the accuracy of the design model is higher. In addition, in the operating environment of the model, the start and end time of the collection program is called to obtain the time consumption of physical fitness information collection. After data calculation and comparison, it is found that the time cost of the model in this paper is less. Comprehensive time-consuming and collection accuracy test results show that the information collection efficiency of the physical fitness information collection model for the elderly based on the Internet of Things technology has improved.

To sum up, the real information collection model of the elderly sports fitness based on the Internet of things technology designed in this paper can not only accurately obtain the health information and movement posture information of the elderly in the process of exercise, but also greatly improve the collection efficiency.

4 Conclusion

This study designed a real information collection model of the elderly sports fitness based on the Internet of things technology, which can accurately obtain the health information and movement posture information of the elderly in the process of exercise, and the collection efficiency has been improved, and the real information collection function of the elderly sports fitness has been effectively realized. When the model is applied to the motion monitoring of the elderly, the alarm can be raised according to the results. In the future research, we can make further intelligent analysis of the elderly fitness data combined with medical knowledge, so as to customize more perfect PC program and mobile phone program, and further improve the effectiveness and applicability of the collection model.

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