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Research Article

Data Analysis of Athletes' Physiological Indexes in Training and Competition Based on Wireless Sensor Network

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The application of physiological and biochemical indicators in athlete training and competition has become a hot research topic in related fields at home and abroad. Both coaches and scientific researchers hope to use quantitative physiological and biochemical indicators to study the load, fatigue, and recovery of athletes in training competitions and use them to scientifically guide athletes in training competitions, improve sports performance, and reduce injuries. This article introduces in detail the development status of wireless sensor network technology, energy consumption detection system, and ZigBee technology. On this basis, the focus is on the design of the detection terminal (coordinator and router node), the routing protocol of the ZigBee network, and the algorithm for the detection of human energy consumption. This subject proposes a design plan for the human exercise energy consumption detection system and researches and designs the wireless sensor network coordinator, router node, and host computer monitoring system. The microprocessors of the two types of network nodes use the single-chip microcomputer. Among them, the router node is composed of sensor modules, data transmission modules, and power modules; the software part is transplanted to ZigBee protocol Z-Stack, combined with the routing algorithm, and we add the corresponding node function code to achieve them. Based on the introduction of the development status and development points of the single-chip-based motion wireless sensor, this article focuses on the analysis of the single-chip-based motion wireless sensor network products. The common features of the single-chip microcomputer are wireless, huge low power consumption, and simple development. Engineering practice shows that the designed system is relatively good in terms of reliability and stability of data transmission; even in the case of severe noise interference and electromagnetic interference, the probability of network nodes malfunctioning is still very small. The router node processes and analyzes the collected motion data, calculates the energy consumption and motion state of human motion based on the acceleration value of each axis and extracts data characteristics, and transmits the obtained results to the coordinator for real-time display.

1. Introduction

With the rapid development of technologies such as communications, embedded computing, and sensors, wireless sensor network technology is becoming more and more mature and its applications are becoming more and more extensive, including video and traffic monitoring, air traffic, automobile and robot control, and smart home and industrial automation [1]. The development of science and technology has brought great convenience to people's life and work, and at the same time, it has also greatly reduced people's activity and exercise volume, causing health problems such as physical weakness [2]. But sports also have certain risks, such as overexercise, muscle strain, and heart attack. Therefore, certain safety monitoring is required during exercise to be able to correctly judge the athlete's health status, prompting and restricting certain some sports. Traditional exercise detection equipment (such as sports tablets, medical monitors, isokinetic exercise devices, and advanced sports training status monitors) have problems such as lack of specificity for athletes, single functions, and inability to carry them [3]. To this end, it is planned to develop and design a multiparameter wireless monitoring system for athletes and strive to achieve convenient carrying and real-time and accurate monitoring of the changes in the main physiological parameters of athletes during training and recovery, and it can be used for the prevention of sports diseases [4].

In order to improve the level of training and prevent and reduce the occurrence of various diseases, domestic and foreign scientific and technical personnel have developed a variety of simulation training equipment and life state monitoring equipment such as sports platform, isokinetic equipment, and advanced sports training status monitor [5]. However, there is still a large space for research and development, such as a multiphysiological parameter wireless monitoring system, which can monitor important vital sign parameters in real time, continuously and for a long time, and transmit the obtained data to the guardian for analysis by the guardian. So that the guardian can make correct judgments on the status of the guardian, so as to correctly handle the guardian, it is very suitable for athletes in a state of free movement and has long been applied to military, medical, and other fields [6]. However, the application in sports and health care is relatively lagging, and common reports mostly appear in the form of wearable smart shirts [7].

This article is supported by modern electronic technology, embedded system, wireless communication technology, and medical knowledge. The article combines mature medical testing technology and athlete's dynamic and physiological characteristics to make up for some of the shortcomings of traditional sports testing equipment. The sports training system designed in this paper is mainly composed of two parts, namely, the motion acquisition sensor module fixed at the bottom of the sports racket handle and the mobile phone APP software responsible for collecting and analyzing motion signals. This paper establishes an embedded development environment to realize the integrated design of hardware circuits. First, it describes the overall design of the wireless sensor network communication module, analyzes the technical indicators of the communication module, and uses single-chip microcomputer as the core processing chip to carry out the modular design of wireless sensor network communication. Regarding the power consumption factor and convenient use of the sensor module, the software design has sensor data collection and at the same time gets rid of the thinking mode that permeates traditional sports detection equipment and still regards the sports object as disease patients, which can meet the needs of competitive sports and mass sports.

2. Related Work

Various physiological signals of the human body, such as electrocardiogram, brain electricity, and myoelectricity, are all microvolt to millivolt signals, which are extremely resistant to interference from the external environment and other human signals [8]. In order to be able to measure, transmit, and process the physiological signals of astronauts, new technologies and new methods must be applied, which has promoted the destruction of human life signal detection methods, such as sensor technology, signal processing technology, communication technology, computer technology, micro technology, and medical science information telemetry disk technology [9]. Subsequently, these prostitutes were transformed from the military department to the civilian field, gradually applying frog studies, clinical infiltration treatment, exercise and health, etc. [10]. In the traditional research on the serve action of ball sports, Singh and Gupta [11] adopted the video shooting analysis method. In the experiment, they used two high-speed cameras and adjusted the data collection of the two cameras to synchronous collection. The acquisition frequency is 200 Hz. Two high-speed cameras collected data on the front and side of sports athletes. The acquisition range is the range of sports serve. Zhang and Liu [12] combined the inertial gyro method and the virtual gyro based on the landmark. The Marker-Based Virtual Gyroscope (MBVG) method is used for the research and analysis of the upper arm's internal rotation during sports serve, and the research results are analyzed and compared with the monitoring results of video shooting. Cabaccan et al. [13] fixed the inertial gyroscope on the upper arm and chest of the sports server, used to collect the movement data of the upper arm during the serve, and then used the Vicon optical motion capture system to set the mark point according to the mark point. The trajectory proposed a vector-based method that combines the motion data collected by the gyroscope to determine the rotation relationship in each direction, so as to conduct a good and effective analysis and evaluation of the sports serve.

Human exercise energy consumption mainly refers to the part of human energy used for muscle contraction to complete mechanical external work. Its detection plays a very important role in predicting the amount of human exercise and improving the way of exercise on this basis. In the early years, Simbeye and Yang [14] pointed out that energy requirements should be based on energy consumption rather than energy intake. The U.S. Department of Defense's Vision Research Projects Agency (DARPA) has invested tens of millions of dollars every year as funding for WSN network technology research, taking WSN network as an important field for research and setting up a series of military sensor network research projects such as sensor networking system and mesh sensor system [15]. In addition, some large-scale IT companies in the United States, such as Intel, HP, Rockwell, and Texas Instruments, gradually intervene in the research and development work in this field through cooperation or initiate corresponding research and development plans. A large number of important research results have been achieved in the miniaturization of sensor nodes, low-power design, network organization, data processing and management, and WSN network applications [16]. The differentiated service mechanism of wireless sensor networks has always been a hot topic in academic research. For different purposes, many scholars have proposed differentiated service models for wireless sensor networks based on application or data classification. Xiong [17] classified data based on neural networks to reduce the amount of data transmission. Sun improved the DAVIC service model in response to the difference in service quality requirements of different services in wireless multimedia sensor networks, using a nonpreemptive priority queuing model, and established a differentiated service guarantee protocol suitable for wireless multimedia sensor networks. In the differentiated service model established by Chen et al. [18], a sensor node classifies other nodes communicating with it according to the deflection angle and combines the network's own structure, topology, and service capabilities to send the data stream to the area that meets its requirements. Tao et al. [19] distinguished the priority of data streams by adding different service weights to different data streams and assumed that the priority of a node depends on the sum of the service weights of the data streams it perceives. In this way, changes in network topology and routing protocols are used to ensure that data flows with high service weights can get sufficiently good QoS. Shao et al. [20] combined the geographic location and priority of the node in the analysis so that the analysis result can accurately reflect the impact of the geographic location of the wireless sensor network on the performance. Some scholars have also studied the application of differentiated service wireless sensor networks based on IEEE 802.15.4 in the monitoring of nonsaturation environments and constructed a classifier to classify the encrypted data in the wireless sensor network in order to improve the QoS performance of the encrypted wireless sensor network [21–23].

3. Model Construction of Sports Wireless Sensor Network Based on Single-Chip Microcomputer

3.1. Function Distribution of Wireless Sensor Protocol. There is always correlation between the data perceived by wireless sensor nodes, mainly including temporal correlation and spatial correlation. Figure 1 shows the wireless sensor protocol functional topology.

Time correlation refers to the correlation between the information perceived by different nodes due to the energy radiation of physical phenomena when different nodes perceive a certain physical property of the same target.

$$C(x) = \sum_{i}^{n} \{x(j)\}, \quad j = 0, \cdots, i, \ n \in N. \tag{1}$$

Time correlation depends on the time-varying parameters of the observed physical properties (such as periodicity and self-similarity). Spatial correlation refers to a large number of wireless sensor nodes deployed in the same sensing area. Due to the high density of nodes (that is, there are many nodes in a unit area), the information sensed by different nodes overlaps and correlates.

$$T = \begin{bmatrix} t_1 & \cdots & t_i \\ \vdots & \ddots & \vdots \\ t_i & \cdots & \dfrac{t_i}{(1-t_i)(1-t_j)} \end{bmatrix}. \tag{2}$$

Both time correlation and spatial correlation can be transformed into the correlation between different data streams perceived by the node, that is, the data carried by a certain data stream can be reconstructed by the data carried by other data streams. Using this correlation to merge different types of data streams into one data stream can reduce the amount of data that needs to be transmitted, improve transmission efficiency, and achieve the purpose of reducing energy consumption.

$$f(i,j) = \begin{cases} \dfrac{1}{1-(i/j)^2} - \dfrac{1}{1+(i/j)^2}, & i > j, \\ \dfrac{1}{1+(j/i)^2} - \dfrac{1}{1-(j/i)^2}, & i \le j. \end{cases} \tag{3}$$

The smaller i indicates the higher the efficiency of fusion. When i reaches the minimum, the network will obtain the maximum aggregated revenue. However, at the sink node (or the receiving end), the reconstruction of the data is always imperfect reconstruction, that is, the amount of data compressed in the data fusion process of one data stream can only be reconstructed from the data part of other data streams. It will cause the data stream to be distorted.

$$g = \frac{f(i_1) - f(i_2)}{r_1} = \frac{f(j_1) - f(j_2)}{r_1 + r_2 + r_3}. \tag{4}$$

Define r as the reliability parameter of the fusion, where f is the information carried in the data stream before fusion and g is the information carried in the data stream after fusion. Therefore, the effectiveness and reliability of the fusion are contradictory to a certain extent. The node itself hopes that the fusion is as effective as possible to reduce its transmission burden. Service reliability also has high requirements, so it must be considered comprehensively according to the network's energy and user needs.

$$Y = \frac{1}{3\sum_{i=1}^{N}\sum_{j=1}^{3}\left|x(i, a_j)\right|}. \tag{5}$$

The fusion function determines the flow characteristics of the data stream after the fusion of each wireless sensor node and is the most important factor that determines the performance of a fusion algorithm. Assuming that the data streams of nodes x and y are fused at node z and the fusion function is f, then the fused data stream is satisfied.

$$\begin{cases} v_1 = v_0 + a_0 * t, \\ v_2 = v_1 + a_1 * t, \end{cases} \tag{6}$$

$$\sum_{i=1}^{N} \sqrt{\sum_{j=1}^{3} x(i, a_j)^2} = s, \tag{7}$$

$$S(x,t) = \frac{T(x,t)}{1-(1-T(x))(1-T(t))} * S(x, t-1), \quad S(x,t) > T(x,t). \tag{8}$$

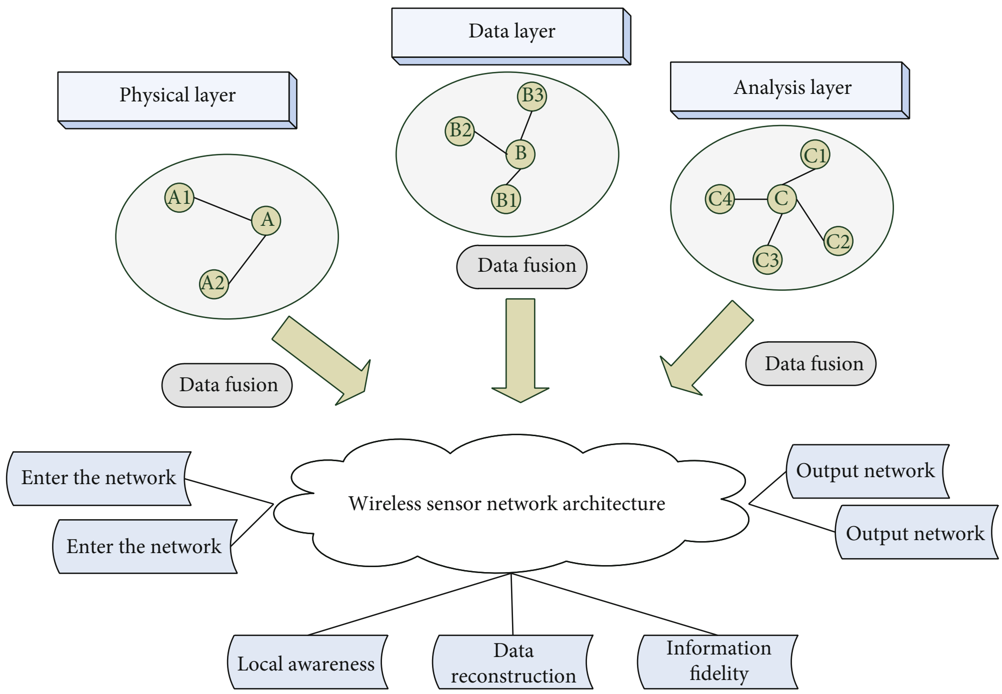

Figure 1: Wireless sensor protocol function topology.

The fusion function determines how much data is lost (or information is distorted) after fusion. A good fusion function should be able to make full use of the limited transmission capacity of the node.

$$H(x,t) \longrightarrow <f_1^*(x,t), a_1^*(t)>, \quad f_1^*(x,t) = f_1 \otimes g_1(x), \quad (9)$$

$$A_g^p(t) = \sum_{i=1}^{k} c(i,p) * f_1^*(x,t), \quad A_i(t) \sim <f_i(x), p(i,t)>. \quad (10)$$

According to the characteristics of the network itself and the performance requirements of the service, the effectiveness and reliability of the fusion are required. It receives the data transmitted by the lower computer and performs verification to verify the correctness of the data and then sends the data to the network where we want to exchange data, analyzes the information, and turns it into commands and data that can be recognized by the network. Wireless sensor networks are always energy-constrained. In large-scale wireless sensor networks, sending data streams sensed by wireless sensor nodes directly to sink nodes will generate a lot of energy consumption, and the transmission efficiency is also low.

3.2. MCU Data Fusion Algorithm. The electricity is converted into stable direct current after passing through the power transformer, rectifier circuit, filter circuit, and voltage stabilizing circuit [23–25]. In this system, since the capacitor plays a role in charging and discharging in the circuit, the value w is relatively large. In order to prevent the electric circuit from being disconnected, the accumulated charge on the capacitor is released. Therefore, it is necessary to connect a large resistance resistor to form a discharge.

$$\frac{\partial w(i,j,k)}{\partial i} + \frac{\partial w(i,j,k)}{\partial j} + \frac{\partial w(i,j,k)}{\partial k} = 0. \quad (11)$$

Figure 2 shows the flow of the MCU data fusion algorithm. The read function steps are as follows: first reset it, write the byte command (OxCC) that skips the ROM, then write the command to start the temperature conversion (0x44), wait for a period of time, and then write and read the scratchpad data command (OxEE). The sensor will send the relevant data to the single-chip microcomputer, and the current temperature value can be obtained by the single-chip microcomputer after corresponding processing. The control core part has two 16-bit timer/counters TO and T1, which are, respectively, composed of 8-bit counters THO, TLO and THI, TLI. They all complete counting by adding "1." The special function register TMOD controls the working mode of the time/counter. TCON controls the start and operation of the timer/counter and records the T0 and T1 overflow flags. The initial values of T0 and T1 can be configured through the initialization programming of THO, TLO, THI, and TLI. Through the initialization of TMOD and TC, the mode word and control word can be operated, respectively, to specify their working mode and control T0 and T1 to count according to the specified working mode.

This signal is used to indicate the status of the internal data register. When the data of the internal data register is ready, the signal pin will go low. After performing a read operation that reads data from the internal data register, this signal pin will go high. In this way, it is possible to prevent

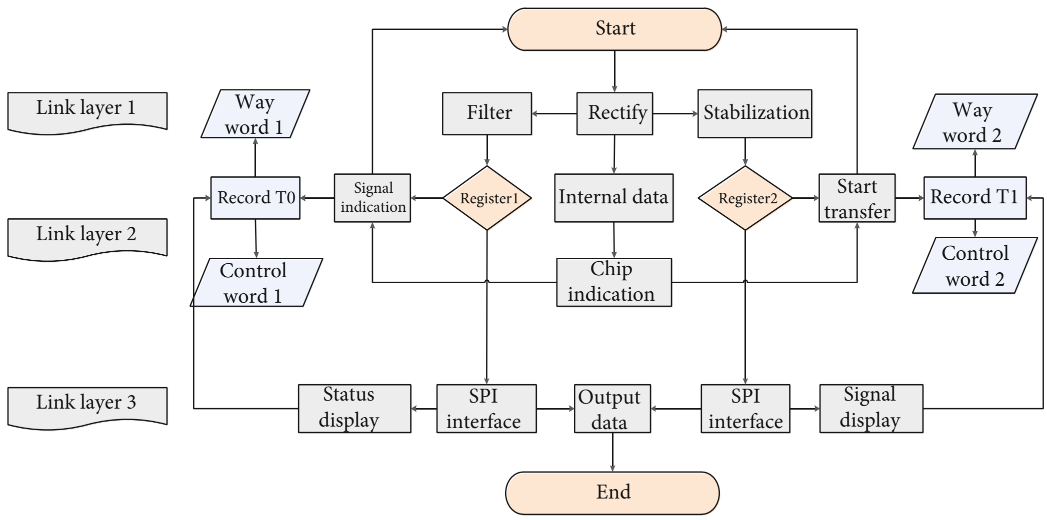

Figure 2: Single-chip microcomputer data fusion algorithm flow.

the data from being read when the register data is updated and to make the output data more accurate and reliable. There are three status output interfaces, providing carrier detection output CD, which is the output terminal of the download wave detection signal in the receiving mode; address matching output AM, which is the output terminal of the chip indication signal after receiving the correct data packet address; data ready output DR. It is the output terminal of the chip indication signal after sending a data packet. In the configuration mode, the microcontroller configures the working parameters of the high-frequency head through the SPI interface. The data acquisition unit uses sensors to collect the information of the object to be tested in the monitoring area; the data processing unit realizes the functions of data analysis, processing, and storage; the data sending and receiving unit is responsible for low-power short-distance node communication; the power supply unit selects miniaturized, high-capacity batteries to ensure the long life and miniaturization of the nodes. In addition, when the wireless module is working in receiving or sending mode, the MCU SPI interface receives and sends related data. The sending and receiving program is the focus and difficulty of this part and even this system. The sending and receiving process will be described in detail below. When the microcontroller has data sent to the regulations, the address and effective data of the receiving node are transmitted to chip through the SPI interface; then, the single-chip microcomputer sets TR_CE and TX_EN to high level to start the transmission.

3.3. Optimization of Network Node Indicators. Since only one temperature sensor is used in a node system, in the case of a single point, the ROM instruction can be skipped directly, and the skipped instruction is OxCC [26, 27]. It is the start temperature conversion command; the converted temperature value will be stored in the first two bytes of the register. OxEE is the instruction to read the register, that is, after the temperature conversion is over, the data will be stored in the register, and the current temperature value needs to be obtained through this instruction. The one-chip computer visits the temperature sensor through the single data bus, must reset it first; in a sense, it is the beginning of a visit to the start signal [28, 29]. The write sequence includes writing 0 and 1 logic. When the microcontroller writes 0 to the sensor, it first pulls the bus low for 15 μs, then continues to pull it low for 15-45 μs in the low-level state, and finally releases the bus. When the microcontroller writes 1 to the sensor, it first pulls the bus low for 15 μs, then pulls it high for 15~45 μs in the high state, and then releases the bus. The counter T1 can start counting from "0," so both TL1 and TH1 are assigned the value of Ox00; because the 16-bit timer T0 can define a time of about 65 ms at most, it can define a time of 50 ms, as long as it recycles 20 times. It should be noted that, since the counter adds a "1" to the counter and generates an interrupt request when it overflows, it is not possible to directly put the count value into the counter, but should send the complement value of the count value.

Figure 3 shows a block diagram of a wireless sensor network detection system based on a single-chip microcomputer. The personal area network composed of the network is mainly composed of terminal sensor nodes, routing nodes, and gateways (coordinator nodes). The sensor node continuously collects human physiological data and transmits it to the routing node through the ZigBee protocol. The routing node is responsible for routing and finally sent to the gateway. The gateway aggregates the data of the ZigBee network and communicates with the external network to control and manage the entire network. The gateway in this paper is the "communication hub" between the ZigBee network and the external control network and is responsible for the mutual communication between the wireless sensor network and the external network.

As the data outlet of the network, the gateway node needs to process a large amount of data compared with ordinary nodes. Therefore, it should have strong computing power, large storage capacity, high speed, and longer communication distance. The choice of gateway is generally guided by specific applications. The hardware platform

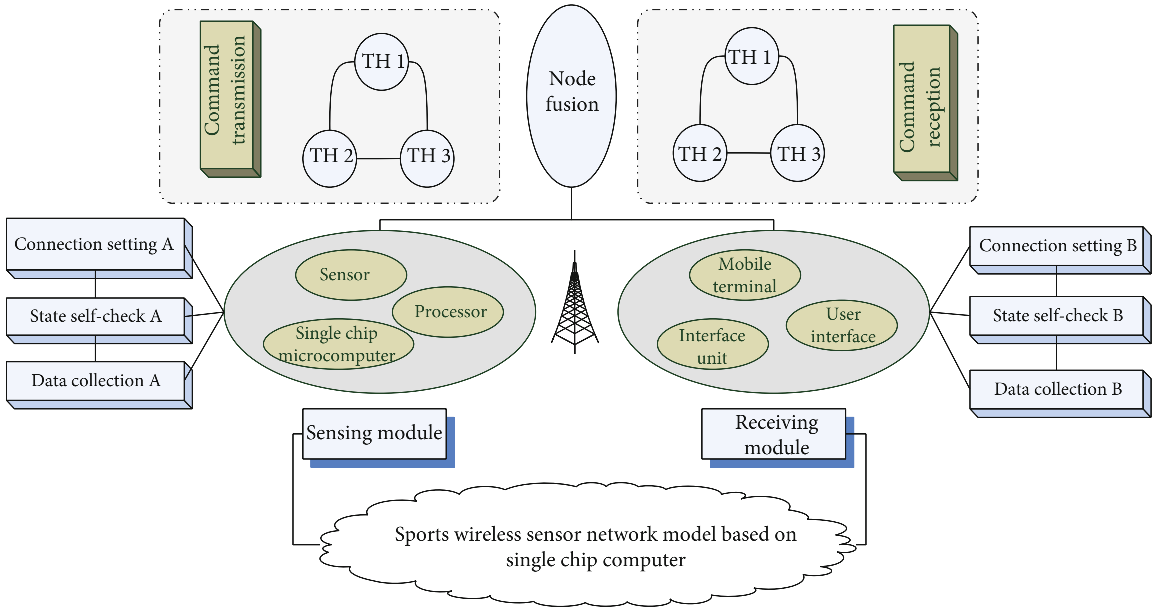

Figure 3: Block diagram of wireless sensor network detection system based on single-chip microcomputer.

should choose low power consumption, powerful processing capabilities, abundant peripherals, a microprocessor that is easy to develop and control, and open in function to facilitate future upgrades.

4. Application and Analysis of Sports Wireless Sensor Network Model Based on Single-Chip Microcomputer

4.1. Performance Data Transmission Preprocessing. Because athletes use a multiparameter wireless monitoring system to collect physiological data for a long time and without interruption, the amount of data that needs to be recorded is relatively large. This article selects the monitoring terminal data memory. This device is a 512 Mb (64 M × 8 bit) NAND Flash memory produced by Samsung. The working voltage is 2.7~3.6 V, the internal storage structure is 528 bytes × 32 pages × 4096 blocks, the page size is 528 bytes, and the block size is 16 kB + 512 bytes; automatic program erasing, page programs, and blocks can be realized; smart read/write and erase operations can read/write or erase the contents of 4 pages or blocks at a time. There is a command register inside. The device can be divided into memory array, input/output buffer, command register, address decoding register, and control logic generation according to function.

This section conducts a numerical analysis of the single node random delay and backlog performance of different priority data flows under different service scheduling algorithms. We suppose a cluster head node receives two data streams A1 and A2, and A1 has a higher priority than A2. The numerical calculations in this section mainly analyze the impact of different service scheduling algorithms on the random performance boundaries of data streams. In order to eliminate the impact of the difference in traffic characteristics between data streams on the analysis results, it is assumed that A1 and A2 meet the same parameter. Figure 4 shows the random delay fan distribution diagram of different priority data streams. Using priority-based service scheduling algorithms can reduce the delay boundary of high-priority data streams under the same boundary function, while the random delay performance of low-priority data streams has not improved, and SP scheduling is better than GPS scheduling effect. This is because the largest data packet is only 1 kbit, and the latency of SP scheduling is very small. However, when the maximum data packet is 10 kbits, the random delay boundary of data stream A1 under GPS scheduling and SP scheduling at this time is given. It can be seen that due to the large latency parameter, GPS scheduling can ensure that data stream A1 has a smaller size. For delay jitter in extreme cases (the boundary function is less than 0.2), the delay boundary is smaller than that under SP scheduling. For the random backlog boundary, the same conclusion can be obtained.

4.2. Realization of Single-Chip System Simulation. This system follows the single power + 5 V power supply mode when selecting devices, which is convenient for power management and simplifies circuit design. Figure 5 shows the comparison of histogram of the voltage threshold conversion efficiency of different sample groups. The monitoring terminal is powered by a battery, and a 3.6 V large-capacity lithium battery is used, which requires the 3.6 V to be boosted to +5 V. The boost chip selects MAX756t211, which is a CMOS process and DC-DC converter suitable for low-voltage and battery-powered systems. The input voltage is 1.1 to 5.5 V, which can be as low as 0.7 V, and then passes through pin 2. Different connection methods of this low voltage are transformed into +3.3 V or +5 V. Compared with similar products, MAX756 has three significant advantages: small size (SMD package with a diameter of less than 5 mm), high switching frequency (up to 0.5 MHz), and

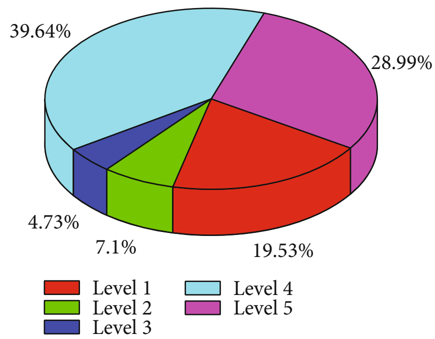

Figure 4: Random delay fan distribution diagram of different priority data streams.

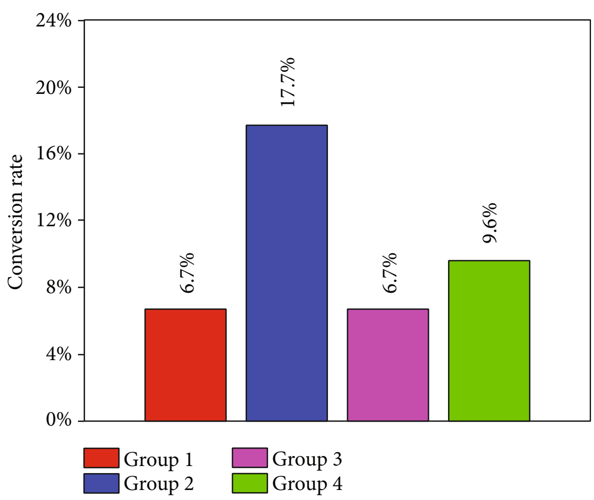

Figure 5: Comparison of histogram of the voltage threshold conversion efficiency of different sample groups.

conversion efficiency up to 87%. The CMOS process reduces the power supply current to 60 μA. When the input is 3 V, it provides 200 mA. In order to prevent the high voltage on the patient from damaging the ECG testing equipment, a TVS tube is installed at the entrance of each lead wire. The TVS tube is also called a transient voltage suppression N-pole tube. According to the above code design, the independent packet address space kernel in the PC realizes the microcontrol of the wireless sensor network communication information storage and performs the wireless sensor network communication performance test. When the voltage exceeds its threshold, a TVS tube is installed. TVS tube has the advantages of fast response time, large transient power, low leakage current, and small breakdown voltage deviation, which can effectively protect the ECG detection instrument from damage caused by transient high voltage.

Considering that the wireless sensor network is a time slot system, the service rate provided by the sink node in each time slot is constant R, and the probability that the cluster head node can communicate with the sink node at this moment is p. From a statistical point of view, the equivalent service rate provided by the sink node to the cluster head node is p. Considering that the vb-type random strict service curve gives the lower bound of the random service, we set the random strict service curve as c. Assuming that all parameters in the network are the same, $r = 500$, $m = 100$, and $c = 0.005$. Figure 6 shows the communication rate curves of sensor nodes at different frequencies. During the acquisition of the ECG signal, due to the 50 Hz power frequency interference, AC common-mode interference is formed in the ECG measurement. This AC interference is usually above a few volts. The current method is to use the right leg drive circuit in the preamplification circuit and the 50 Hz trap in the subsequent circuit. The right leg drive circuit is composed of a common-mode sampling drive circuit, an operational amplifier TLC2252, and a current-limiting resistor. The average AC common-mode voltage is taken out by the common-mode sampling drive circuit and sent to the TLC2252 for inverting amplification and fed back to the right leg of the human body through the current-limiting resistor electrode; this negative feedback effectively reduces the common-mode voltage. We conduct a wireless sensor network communication performance test. In order to compare the performance, we use the system designed in this article and the traditional method to trigger in the embedded system. The CONVST module of the single-chip computer uses the communication error rate as the test indicator to obtain the simulation result. In order to compare the performance, the system and traditional methods designed in this article are used, and the communication error rate is used as the test indicator to obtain the simulation results. It can be seen that using the wireless sensor network communication designed in this article reduces the bit error rate, improves the reliability of communication, and improves the fidelity performance of wireless sensor network communication.

With the right leg drive circuit, since any displacement current flowing into the human body is basically equal to the driving current on the feedback resistor, it can be ensured that when the displacement current flows into the human body, the potential of the human body is basically maintained at zero so that the 50 Hz common-mode interference can be avoided. The voltage drops below 1%. And the human body is effectively grounded, which further improves the common-mode rejection ratio of the preamplifier.

4.3. Example Application and Analysis. After demand analysis and hardware and software selection, the overall plan of this gateway is to choose the most cost-effective chip as the MCU in the hardware, MRF24J40MA as the ZigBee wireless radio frequency module, EM310 as the GPRS module, with the necessary peripheral module circuits. The software is modified on the basis of Microchip's ZigBee open source protocol stack, and the collected physiological data is transmitted to the gateway through ZigBee, and then, the SMS and GPRS communication programs are written and transmitted to the server through the GPRS network. Through the detailed design of hardware and software, the function of the gateway obtained from the previous requirement analysis is achieved, and the system function test and performance test are used to verify it.

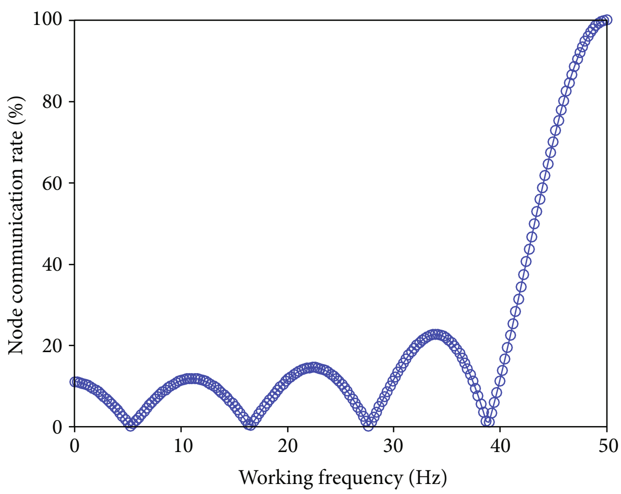

FIGURE 6: Communication rate curve of sensor nodes at different frequencies.

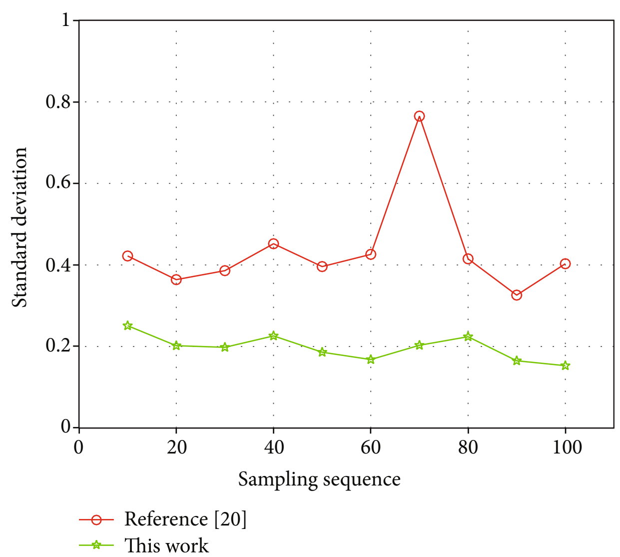

FIGURE 7: Line chart comparing standard deviations of different sampling frequencies.

Figure 7 shows the line chart comparing standard deviations of different sampling frequencies. It can be seen from the figure that the algorithm proposed in this paper has a small statistical deviation in the data processing process and shows excellent performance compared to the references. According to the sampling frequency of the lower computer and the average time of each action, the width of the sliding window is set to 80 groups of data for each window, and each group of data has 6 data, so it forms an 80×6 matrix. In order to exclude data that is not a hitting action, it is necessary to judge whether there is a hitting action in the window. Through experimental analysis, the basis for judging whether there is a hitting action is the average value of the absolute value of acceleration and the sliding variance of angular velocity. Under the priority-based scheduling algorithm, the quality of service of high-priority data streams can be guaranteed. However, in the actual wireless sensor network, due to the random nature of the network, the priority of the data stream being transmitted in the network is always constantly changing. Therefore, when the cluster head node receives a data stream, it is difficult to base on the existing data stream. The priority of the data stream is used to determine its priority. After judging that there is a hitting action, the action window can be intercepted; otherwise, the sliding window will slide down. The selection strategy of the action window is to take the peak point in the sliding window that is judged to have a hitting action as the hitting point, taking the hitting point as the center and selecting 40 sets of data as the action window. Figure 8 shows the error statistical distribution of the sensor network training system. After the action window is selected, the feature value of the motion window must be extracted.

The eigenvalues selected by the training system mainly include mean, variance, standard deviation, peak value, covariance, correlation coefficient, skewness, and exercise intensity. It can be seen from the error scatter line chart that the algorithm proposed in this paper has small statistical errors in the data processing process, the error distribution is relatively scattered, there is no significant linear orientation, and it shows excellent robust performance. Some features like root mean square (RMS) and absolute mean square deviation (MAD) have proven to be very effective. Figure 9 shows the comparison curve of data deviation before and after filtering at different sample points of the sensor network.

The random delay performance of the data stream keeps getting better with the increase of the sink node's moving speed. This is because as the sink node moves faster, the probability that the cluster head node can communicate with the sink node in a time slot increases, so it is equivalent for the random service will increase. At the same time, it can be seen that when the moving speed of the sink node is increased from 10 to 20, the speed has doubled, and the delay performance has also increased by 12.5%. However, when the speed is increased from 20 to 40, the speed doubles, and the delay performance is only improved by 23.5%. That is, as the sink node's moving speed increases, the gain of the delay characteristics keeps getting smaller. After testing the ZigBee wireless sensor network of this system in the school playground environment, it can be seen that the maximum communication distance between nodes is small. The system debugging results show that the communication module of this design has better stability for wireless sensor network communication, lower communication error rate, and higher reliability of the circuit system. Because the working environment of the system is relatively single, there are fewer interference factors and obstacles blocking the transmission. The distance is short and the system has strong working stability, so it can basically meet the application requirements of the wireless human energy consumption data collection system.

Figure 10 shows the comparison curve of the communication delay performance of nodes before and after the algorithm is applied. The host computer monitoring system runs stably and can effectively receive and quickly store data. The

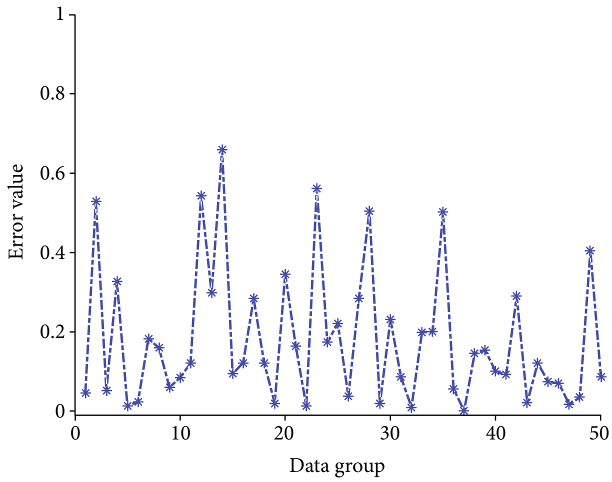

FIGURE 8: The statistical distribution of the error of the sensor network training system.

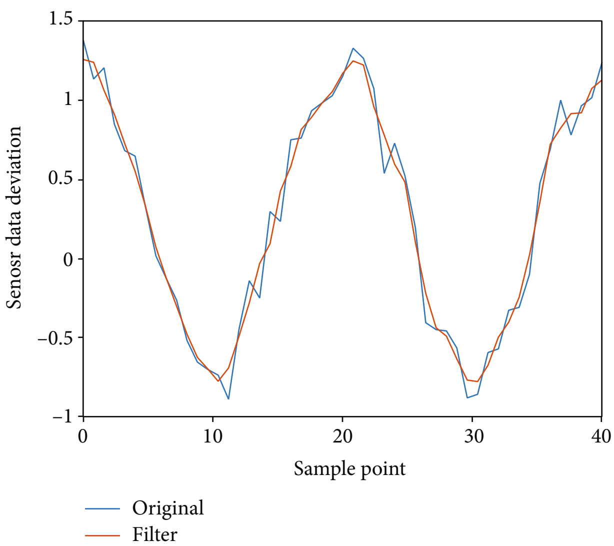

FIGURE 9: Comparison curve of data deviation before and after filtering at different sample points of sensor network.

data is received through the serial port debugging window. The online score display window organizes the scattered data and displays it. We can see the scores of router nodes that have joined the network. By adding network node equipment, the communication port can greatly extend the response to the reader node distance. Before and after the algorithm is applied, it can be seen that the priority-based service scheduling algorithm can reduce the delay boundary of the high-priority data flow under the same boundary function, while the random delay performance of the low-priority data flow has not improved, and the scheduling has better results. Due to the increase of node redundancy, the reliability of transmission can also be improved, but the intermediate transfer reader node returns a response to the host computer node. Using the wireless sensor network communication designed in this paper, the error rate is reduced, the reliability of communication is improved, and

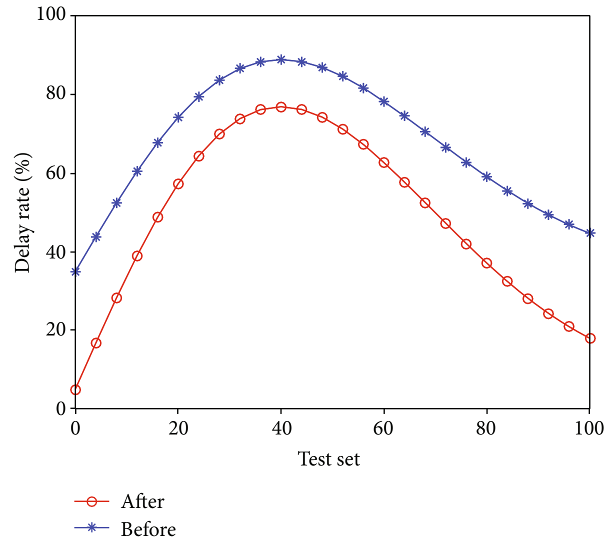

FIGURE 10: Comparison curve of node communication delay performance before and after algorithm application.

the fidelity performance of wireless sensor network communication is improved. In practical applications, comprehensive consideration is given to using the host computer node to receive the response and return it to the host computer through the serial port. The same communication gain antenna and increase the number of nodes to increase the transmission distance.

5. Conclusion

This paper studies the services provided by wireless sensor networks based on differentiated services to data streams after fusion, focuses on deriving the random residual service curves obtained by different types (that is, different priorities) under service scheduling algorithm, and establishes a classification based on data streams. The random service competition model and the result are extended to the scene of multicluster head node collaboration. The analysis process takes into account the independence between data flow and service. According to the characteristics and functional requirements of the human body motion energy consumption detection system, the routing scheme of the coordinator in the system, the data collection and display principle of the router node, and the data transmission and communication protocol between the detection terminals of the system are described and selected. By introducing relevant parameters to measure the correlation between different types of data streams, the fusion properties of traditional random network calculations are improved, and then, a random arrival model after the fusion of different types of data streams is established when the sum fusion algorithm is used. After testing, it is feasible to use ZigBee wireless network to realize serial transparent transmission, and the performance fully meets the small data transmission of general wireless sensor system. ZigBee network is simple to implement, has high reliability, and has low cost. It is a good supplement to wired transmission. Therefore, the use of a wireless sensor network-based human exercise energy consumption detection system is the future development direction of the human exercise energy consumption detection system. The system debugging results show that the communication module of this design has better stability for wireless sensor network communication, lower communication error rate, and higher reliability of the circuit system. The research is based on the application of wireless sensor networks in human motion detection which is of great significance to the modernization and intelligent movement.

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 known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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