Hindawi
Journal of Sensors
Volume 2023, Article ID 9801928, 1 page
https://doi.org/10.1155/2023/9801928

Retraction

Retracted: Wireless Sensor Network Topology Theory for Data Collection and Analysis of Sports Training Human Body

Journal of Sensors

Received 3 October 2023; Accepted 3 October 2023; Published 4 October 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] B. Fu, "Wireless Sensor Network Topology Theory for Data Collection and Analysis of Sports Training Human Body," *Journal of Sensors*, vol. 2021, Article ID 9746107, 13 pages, 2021.

Hindawi
Journal of Sensors
Volume 2021, Article ID 9746107, 13 pages
https://doi.org/10.1155/2021/9746107

Research Article

Wireless Sensor Network Topology Theory for Data Collection and Analysis of Sports Training Human Body

Beibei Fu

Henan University of Urban Construction, Pingdingshan 467000, China

Correspondence should be addressed to Beibei Fu; fubeibei@hncj.edu.cn

Received 6 September 2021; Accepted 19 September 2021; Published 8 October 2021

Academic Editor: Guolong Shi

This paper is based on wireless sensor network topology for sports training human data collection, and the collected data are studied and analyzed in depth. According to the application requirements of sports training, a sports training system consisting of an embedded data collection terminal, and a database server is designed using wireless sensor network technology. The hardware is designed with sensor nodes and base stations to collect athletes' motion parameters in real time. The software is designed with node and base station control software and sports database management system to realize the receiving, storing, and analyzing of sports parameters. And the system experiments were conducted, and the experimental results show that this system meets the application requirements of sports training and provides an effective tool for scientific training decision research. The needs of designing sports training systems under wireless sensor networks are analyzed, and the system is designed and implemented. Our results confirm that the use of wireless sensor network technology in the design of the sports training system improves the system application performance by 16%. And the interactivity of the sports training system in practice has increased by 8%. All of these show that the design of the sports training system under the wireless sensor network meets the actual system application requirements and has a positive impact. The design of base station control, node control, and sports database software is implemented in the software system, which can effectively realize the collection, storage, and analysis of sports parameters. Finally, the designed wireless sensor network-based sports training system is tested, and the test results indicate that the system designed in this paper can meet the needs of sports training use.

1. Introduction

In the process of continuous development of modern information technology, it has a certain influence on the more competitive modern competitive sports, and the use of information technology can realize the scientific nature of sports personnel training. In the process of traditional sports training, it is through the coaching staff to record and observe athletes' sports data and judge the reasonableness of the sports according to their own experience [1]. This kind of qualitative analysis method is highly subjective, with large errors and easily disturbed. The combination of modern information technology and traditional training methods and experience can combine the quantitative parameters of athletes in the process of sports, to achieve the timely acquisition of athletes' sports parameters, and make the computer effectively statistical processing, to provide accurate sports analysis results for athletes. Based on this, this paper provides a comprehensive analysis of the design of sports training systems in wireless sensor networks [2]. Judge the rationality of the exercise based on your own experience. This qualitative analysis method is highly subjective, with large errors and easy to be disturbed. Wireless sensor networks are formed because of the combination of computing, communication, and sensor technologies. In wireless sensor networks, not only sensor technology and embedded computing technology are used in an integrated manner but also distributed information processing technology and communication technology are included to play an active application value [3], in practice, for wireless sensor networks, mainly not only by the random distribution of many integrated sensors as well as data processing units and wireless communication modules consisting of tiny nodes, between its nodes, but also through the self-organization form to form an ineffective communication

network to improve the efficiency of the actual information dissemination [4]. In the wireless sensor network, a variety of modern technologies are integrated, and the network can be used to collect, sense, and process information about objects in the network coverage in real time and send this information to the corresponding observers, which has practical application advantages.

The rapid development of information technology has had an unprecedented impact on the competitive modern competitive sports, and the use of information technology to assist athletes in scientific training has become an important symbol of modern competitive sports. In the traditional sports training method, coaches are mainly responsible for observing and recording athletes' sports data and judging the rationality of sports techniques by experience. This kind of qualitative analysis method has disadvantages such as strong subjectivity, large errors, and easy interference. By combining information technology with traditional training methods, experience, and historical training data, the quantitative parameters of athletes' movements can be obtained in a timely and effective manner and handed over to the computer for statistical processing, providing a theoretical basis for accurate sports technology analysis. Based on the latest theoretical achievements in wireless sensor networks, the book discusses and summarizes the development, applications, and technical challenges of wireless sensor networks based on authors' long-term research work in this field. The book has a clear structure, rich content, and an in-depth narrative, reflecting the latest research progress and results in the field of wireless sensor networks; it can enable interested beginners to get started quickly and also provide colleagues with a certain research base to provide more systematic-related technologies or programs to make up for the relative lack of systematic research materials in this field, help readers to deepen their understanding of wireless sensor network technology, and provide a better understanding of wireless sensor networks. With the significant decrease in price, smaller size, and increased sensitivity of various sensors such as acceleration sensors and gyroscopes in microelectromechanical system (MEMS), there has been a great breakthrough and development of human motion recognition system based on sensors [5]. Human motion recognition technology has also focused on by many researchers, and its principle refers to the use of different sensors to collect various data information about the daily activities of the human body, then preprocess and analyze the information based on the collected data to extract the corresponding feature vectors, and finally, use specific recognition algorithms to identify and determine the motion. The increase in accuracy of sensor-based human motion recognition algorithms also makes it a new technology for daily life monitoring of the elderly.

Due to the particularity of the application environment of sensor networks, unstable wireless signals, and limited energy, the probability of damage to sensor network nodes is much greater than that of traditional network nodes. The topology control technology is one of the most important technologies in wireless sensor networks. In the network topology generated by the wireless sensor network, there is a topological edge between two nodes that can communicate directly. If there is no topology control, all nodes will work with the maximum wireless transmission power. In this case, on the one hand, the limited energy of the node will be quickly consumed by the communication components, reducing the life cycle of the network. At the same time, the wireless signal of each node in the network will cover many other nodes, causing frequent wireless signal conflicts, affecting the wireless communication quality of the nodes, and reducing the throughput rate of the network. On the other hand, there will be many edges in the generated network topology, resulting in a large amount of network topology information, complex routing calculations, and wasting valuable computing resources. Therefore, it is necessary to study the topology control issues in wireless sensor networks. Under the premise of maintaining certain global properties of the topology, adjust the transmission power of the nodes to extend the network life cycle, increase network throughput, reduce network interference, and save nodes. Therefore, the robustness of self-organizing networks is necessary to ensure some sensors. It also includes distributed information processing technology and communication technology to play an active application value. In actual work, wireless sensor networks, it is mainly composed of many randomly distributed small nodes integrated with sensors, data processing units, and wireless communication modules. Between the nodes, an invalid communication network can also be formed through self-organization. The damage to the network will not affect the progress of the global mission. In the existing human motion recognition system, if only a single acceleration signal is collected, only simple motion movements such as stationary, walking, and running can be recognized due to the single signal, but the diversity of the objective environment and the complexity of human motion make some human motion impossible to be recognized accurately. In the method of human motion recognition based on multiple sensors in one node, general researchers have modeled human motion by placing multiple sensor nodes on different parts of the wearer, collecting different data information, and uploading the data to the PC; although this method will have a great improvement in the accuracy of human motion, the system is too complex and not suitable for human carrying. The overhead of transferring data and human body reconstruction system at different nodes is large and not suitable for moving to a portable terminal. According to the diversity of collected data, researchers have extracted effective data features based on their collected data and proposed some pattern recognition algorithms based on various complex data features, but recognition algorithms with higher recognition accuracy are generally more complex leading to system algorithms that are difficult to move to portable terminals. To obtain a high recognition rate, a large amount of sensor data as well as complex algorithms are applied, which will lead to an increase in the energy consumption of the system, and the energy of the sensor nodes is limited, which will lead to frequent charging or replacement of the power supply, thus greatly reducing the comfort of human wear. (1) Through the collection and analysis of human body data for sports

training under the wireless sensor network topology, we found that our training accuracy has increased by 16%. (2) Compared to other studies, our efficiency has increased by about 8%.

2. Current Status of Research

The vision-based human motion recognition method is to install the filming equipment inside a fixed space and determine the human motion state by analyzing the human motion state in the filmed pictures and the comparison of the before and after pictures; its technology started earlier, and the theoretical research is more mature; from the existing research, its system algorithm complexity and recognition accuracy can meet the daily needs [6]. A big shortcoming is that the environmental requirements for acquiring images are relatively strict [7]. The acquisition of human motion images requires a spacious environment and sufficient light, and that the subject is not obscured. The sensor-based human motion recognition system is a new development direction of pattern recognition in pattern recognition. Its basic principle is to collect the motion data information from one or more miniature sensors carried by the user and then make corresponding recognition and judgment on the motion of the human body according to the data special. Sensor-based human motion recognition has little dependence on the environment and is not affected by the image capture equipment and can be collected at any time and any place [8]. Therefore, when collecting the data information of human movement, the human body can move freely and collect the data that is more in line with the real situation, and there is no need for other peripheral devices to interfere when obtaining user's data, and the data of the corresponding movement can be obtained as long as the user moves, such as lying down, going to bed, and going to the bathroom, and will not violate user's privacy.

Olivia et al. used a single acceleration sensor to collect data by extracting the amplitude values of the triaxial acceleration sensors as data features, and the recognizer used a neural network recognition algorithm to recognize falls in different directions, in which the recognition accuracy reached 95.5% [9], to help readers deepen their understanding of wireless sensor network technology and lay the necessary foundation for further study and research in the field, to shorten the gap between the first-class international research level in the field, and to contribute more research results with our intellectual property rights. Belapurkar et al. used a single three-axis acceleration sensor to collect acceleration values in three directions, calculated the root-mean-square value of acceleration in three directions, and derived the change of acceleration in each direction to detect falls, with an accuracy of 86.97% [10]. Hara et al. fixed the acceleration sensor module on the crotch of the human body and used the pattern recognition method of support vector machine to identify four types of falls: stationary, walking, running, and jumping [11]. Soares et al. used a support vector machine pattern recognition method to accurately recognize four types of movements, stationary, walking, running and jumping, and the recognition accuracy reached 92.25% [12]. A sensor-based human motion recognition system was designed and proposed to put acceleration sensor, gyroscope sensor, and magnetometer sensor on the same node and fuse the three sensors in one node to recognize human motion [13]. SriGowthem used a three-axis acceleration sensor and gyroscope sensor module to collect human motion information and proposed a human motion recognition algorithm based on acceleration sensor and gyroscope sensor-based human motion recognition algorithm, proposed a solution method to calibrate the human pose angle, and proved the superior performance of their algorithm through experiments [14].

The sensors that are now used to collect human motion data information are mainly pressure sensors, acceleration sensors, and gyroscope sensors. Different researchers have placed sensor nodes at different locations to collect data information about different human motions [15]. There is no unified database or special hardware technical standards in the existing recognition systems, so researchers generally have to design and select the sensor modules that meet their system performance according to their scientific requirements and experimental goals and handed over to the computer for statistical processing, providing a theoretical basis for accurate sports technical analysis. The sensor module designed by Mayer and Baeumner in the UK uses accelerometer and gyroscope sensors to recognize the motion of the human body at rest, sitting down, and other movements [16]. Existing researchers can not only collect human motion information through self-developed sensor modules in addition to the existing hardware platforms available in the market to collect data. It has been found that a common problem with existing data acquisition modules is that the energy of the system is limited, which can reduce the comfort of the wearer if the battery needs to be replaced or recharged frequently.

3. Design of Sports Training Human Data Collection and Analysis under Wireless Sensor Network Topology

3.1. Wireless Sensor Network Human Data Collection Analysis. Human motion recognition systems are widely used in medicine, health care, sports, military, and entertainment, so they need to process data accordingly and identify and develop applications according to the needs of the system. Their devices are mainly PCs or cell phones, and the main functions they need to achieve are to be able to receive and dynamically display the data collected by the sensor terminal in real time, as well as data query and storage, etc. For example, the monitoring center of the fall detection system is to achieve real-time detection and alarm; the main application in the sports industry is to analyze the amplitude and form of human motion [17]. The essence of sensor-based human motion pattern recognition is to first collect a large amount of sensor data information, train the recognizer to meet the system recognition system according to the collected data, and finally, use the trained recognizer to recognize some unknown human motion data information. The

main steps include data acquisition, data preprocessing, feature extraction and selection, and recognizer selection. The process is shown in Figure 1.

The signals generated during human motion captured by accelerometer and gyroscope sensors, due to human jitter, environmental factors, and equipment measurement bias, make the measured data include not only data information of human motion but also various unavoidable noises. The measured data not only includes the data information of human movement but also contains various unavoidable noises. To reduce the influence of noise on the system, it is necessary to carry out effective preprocessing before data feature extraction. The existing preprocessing methods mainly include filtering processing and normalization processing for denoising, and windowing processing for reducing signal length. To reduce the impact of noise on the system, effective preprocessing is therefore required before performing data feature extraction. The existing preprocessing methods include filtering and normalization for noise removal and windowing for signal length reduction. In sensor-based human motion recognition systems, data denoising and data smoothing are generally used. The jitter of the human body and the jitter of the equipment when collecting the sensor data information will bring the noise to the system and the measurement noise of the system is included in the collected sensor data information, so removing the interference noise will improve the effectiveness and reliability of the system.

Normalization is also a technique often used in preprocessing. The main function of the normalization method is to adjust the motion data of different intensities (such as the amplitude of acceleration signal and the amplitude of angular velocity signal) according to the specificity of the signal. In human motion recognition systems, the differences in height, weight, and age of human beings can lead to certain differences in the amplitude values of motion data information for different people doing the same motion, so some researchers use normalization to reduce the impact of signal amplitude differences on the system [18–21]. An analysis method of human health data is given, including uploading the collected data, analyzing the uploaded data, and analyzing the parsed data; the analysis method is as follows: divide the data collected in each cycle into the highest value of the period, the lowest value of the period, the start value of the period, and the end value of the period expressed in the form of a candlestick chart; the candlestick chart of at least two periods is formed into a candlestick chart; the steps of the analysis are as follows: through a candle in the candlestick chart. The height of the candle head, candle foot, and candle body of the chart is used to determine the data upload frequency. The candle head, candle foot, and candle body height of multiple candle charts in the candlestick chart are used to determine the relationship between the data upload frequency of multiple periods and the trend and maintenance of statistical data. The features of the extracted acceleration data signals were normalized before, and the accuracy of the recognition results was verified by experiments. Data can be collected in many ways. Therefore, some researchers use normalization processing to reduce the impact of signal amplitude differences on the system. For example, making survey questionnaires, randomly selecting population samples to fill in the questionnaires, and obtaining feedback data from the population samples, manual observation records are also a common data collection method in the past. In the data age today, sensors have greatly changed the scene of manual observation and recording of such data collection, especially the objective indicators that are easy to quantify and measure such as temperature and humidity. Although the data of human subjective consciousness still needs to be obtained through questionnaire surveys, the author believes that soon, human thoughts will also be quantified with the advancement of science and technology. At that time, humans only need to think in their brains, not means that the thoughts in the brain can be quantified and recorded.

Since the input data for human motion recognition are usually motion data signals that have been collected from the user for some time, the length of the input data is generally very long and not suitable for direct feature extraction and classification, so the collected sensor data information is usually first windowed before feature extraction is performed on it. The function of windowing is to split the longer sensor data signal into many windows with the same or different lengths [22–24]. The characteristics of the extracted acceleration data signal were normalized before, and the accuracy of the recognition results was verified through experiments. In the existing research, there are two main methods of windowing commonly used in human motion recognition systems: sliding window segmentation refers to segmenting the motion signal acquired by the sensor into windows of the same length, and the adjacent windows may or may not have overlap. As shown in Figure 2, to ensure the integrity of data information at the data edge, there is generally some data overlap in the adjacent sliding windows.

Adding windows to the sensor data will not only make the length of the collected data shorter but also fix the length of the sensor data signal between different people, which is very important for the later data feature extraction, selection, and pattern recognition. When using fixed window length, no additional processing of data is required, and it is often used in systems with high real-time requirements. This is very important for subsequent data feature extraction, selection, and pattern recognition. When using a fixed window length, there is no need to process the data, and it is often used in systems with high real-time requirements. A body monitoring device has a surface and is configured to be applied to the body and/or near the body. Light is emitted in the direction and wherein at least one photodetector is configured to detect light emitted by at least one light source and reflected by the body in a direction toward the surface. However, this window segmentation technique also has certain shortcomings, which makes it difficult to recognize the transition between different actions when two motion signals appear in one window. The motion window-based segmentation technique refers to the processing of data and preliminary judgment to determine the start time and end time of the motion, and the data will be divided into

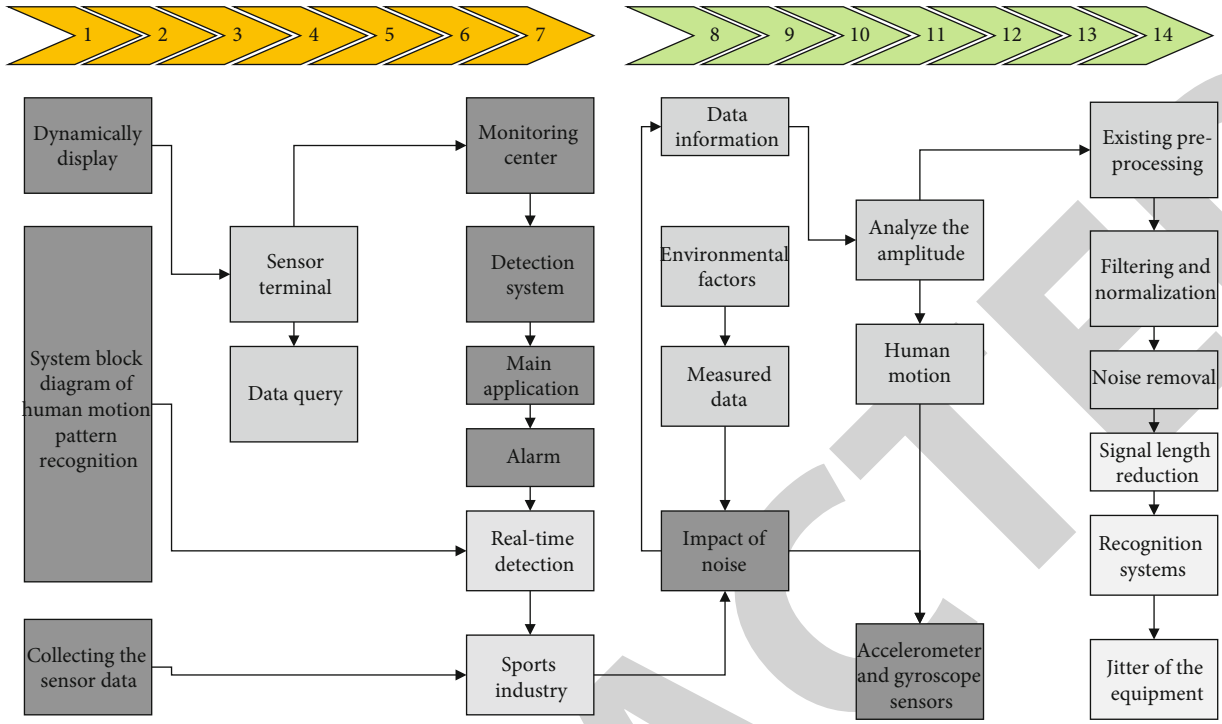

Figure 1: System block diagram of human motion pattern recognition.

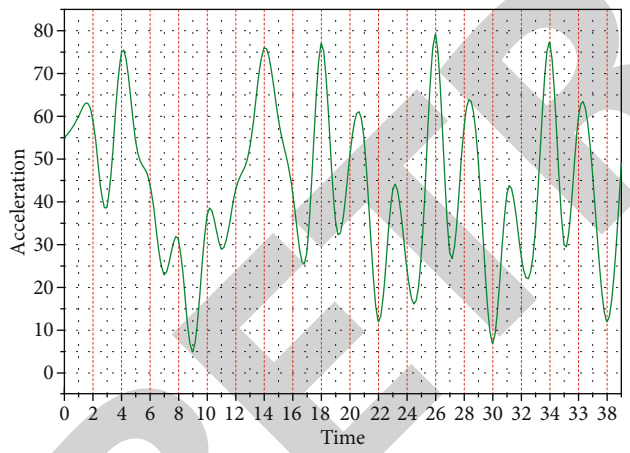

Figure 2: Schematic diagram of division based on fixed window length.

different lengths of windows according to the time of the motion, where each window represents a complete motion. The window technique can accurately identify each motion, but the data needs to be processed and analyzed in the early stage, which will bring a great impact on the complexity of the algorithm and the energy consumption of the system.

Some existing human motion recognition algorithms are required to use the sensor data of the three directional components of the sensor, so some researchers have used the direction of acceleration when the human body at rest has been vertical down to correct the tilt problem of the sensor, that is, tilt correction. The principle of tilt correction is to calculate the tilt angle of sensor placement by using the feature that the direction of gravitational acceleration is always downward. However, this window segmentation technology also has certain shortcomings. When two kinds of motion signals appear in a window, it is difficult for the window segmentation technology to recognize the transition between different actions. The extraction and selection of feature vectors in the human motion recognition system are closely related to both the complexity of the recognition algorithm and the accuracy of the system recognition. In other words, acquiring effective feature vectors from the extracted acceleration sensor data and gyroscope sensor data will reduce the complexity of the classifier algorithm as well as improve the recognition rate of the system. The purpose of feature selection is to extract the most effective and suitable feature vectors that represent human motion based on the collected sensor data. Although there is no unified theory of feature value extraction, the existing methods for extracting feature vectors are mainly classified into the time-domain method, frequency-domain method, and time-frequency method. Descriptive data analysis can be summed up in a single sentence: "one sentence describes the data". We usually say what is the average number of visits this month, what is the year-over-year increase, what is the average user payment, and are median, plural, and quartiles all descriptive statistics? The variance and standard deviation can also be used to describe the concentration trend of the data. The attitude calculation algorithm belongs to the category of data fusion, that is, the fusion of multiple sensor data to calculate the attitude. This article refers to the measurement of the acceleration and angular velocity of the bone point, and the posture information of the bone point is obtained after

data fusion. Use an indicator, a sentence to summarize the characteristics of the data. Mathematical statistics involves more mathematical knowledge, but commonly used are also probability theory and calculus, and undergraduate knowledge, a little review or easy to master. Calculus only requires the use of a unitary integral, which is used to calculate the probability distribution. There are many elements in statistics; not all of which need to be mastered in data analysis, because we are not doing the data analysis of scientific experiments in the laboratory.

Although the change of object attitude can be expressed by the Eulerian angle, it is more complicated in conceptual understanding, and because technical problems such as "universal lock" can occur in the solution process, so Eulerian angle is widely used in the study of rigid bodies in classical mechanics, and the study of angular momentum in quantum mechanics, and in practical products, both use the quadratic method to represent the object motion posture. Just as complex numbers can represent a two-dimensional space, the set of quaternions can represent a four-dimensional space. The basic form of the quaternion is shown in Equation (1) by involving I, j, and k as a special imaginary unit, where i, j, and k denote imaginary units and are orthogonal to each other, and a_i, b_j, c_k are coefficients in each direction. q_0 is a quadratic scalar indicating the rotation angle? When $q_0 = \cos\theta$ and $q = \sin\theta$, this quaternion is said to be the unit quaternion. The rotation vector u can be achieved by multiplying a unit quaternion and its conjugate quaternion with the vector u (as shown in Equation (2)).

$$q = a_i + b_j + c_k + q^*, \tag{1}$$

$$v = q \otimes u \oplus q^*. \tag{2}$$

Taking the conjugate value of a quaternion q is equivalent to rotating the coordinates of q by 2θ.

$$Q \otimes P = q_0 - q_1 l + q_2 J. \tag{3}$$

The quaternion form of the rotation matrix can be obtained as follows

$$\begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix} = R_2 \begin{bmatrix} u_x \\ u_y \\ u_z \end{bmatrix}. \tag{4}$$

By the above reasoning and transformation, the quaternion representation of the pose information is obtained. Compared with the three-dimensional orthogonal matrix representation, the quaternion representation can give the rotation axis and rotation angle more easily. The quaternion method is widely used in industry because there is no singularity in the process of application and there is no "universal lock" problem. The quaternion method and Euler angles can be directly transformed to each other. The reference coordinate system x-y-z is represented by the quaternion, and the cross-roll angle is rotated α, the pitch angle is rotated β, and the yaw angle is rotated γ as shown in

$$\begin{bmatrix} p_0 \\ p_1 \\ p_2 \\ p_3 \end{bmatrix} = \begin{bmatrix} \cos\dfrac{\gamma}{2} \\ 1 \\ 1 \\ \sin\dfrac{\gamma}{2} \end{bmatrix} \begin{bmatrix} 0 & \cos\dfrac{\gamma}{2} & \sin\dfrac{\gamma}{2} & 0 \end{bmatrix}. \tag{5}$$

The above transformations allow fast computation of object's pose process and visualization of the results in terms of Euler angles during the presentation. The pose solving algorithm belongs to the category of data fusion, i.e., a fusion of multiple sensor data for pose solving. In this paper, it means that the acceleration and angular velocity of skeletal points are measured, and the skeletal point pose information is obtained after data fusion. Kalman filter (Kalman filter) is a recursive filter that can efficiently make the state of a dynamic system from a series of incomplete and noise-containing measurements. Therefore, when analyzing the overall physical fitness trend of the whole school, this article chooses to see what kind of changes each person has made based on their original scores and calculates its proportion in the whole. The Kalman filter was named after the early researcher Rudolf Kalman who made the main research on this filtering method. Kalman filtering is an important topic in control theory as well as in control system engineering. Let X_k be the estimated state of the system at time t_k, then the discretized system state equation is shown in

$$X_K = \phi_{k,k+1} - \Gamma_{k+1} W_{k+1}. \tag{6}$$

The measurement equation is shown in

$$Z_k = H_k X_K - V_K. \tag{7}$$

According to the above characteristic analysis, sensor networks need to design network architecture adapted to their characteristics according to user's demand for the network and provide a unified technical specification for the standardization of network protocols and algorithms so that they can meet user's demand. The communication architecture of the wireless sensing execution network is shown in Figure 3, namely, the horizontal communication protocol layer and the vertical sensor network management surface. The communication protocol layer can be divided into the physical layer, link layer, network layer, transport layer, and application layer. The network management plane can be divided into energy management plane, mobility management plane, and task management plane. The management plane exists mainly to coordinate the functions of different layers to obtain an optimal design with comprehensive consideration in energy management, mobility management, and task management.

Figure 3 shows a schematic diagram of the general construction of the sports training system, which monitors many sports and physiological parameters of the athletes, such as speed, acceleration, ECG, and blood pressure,

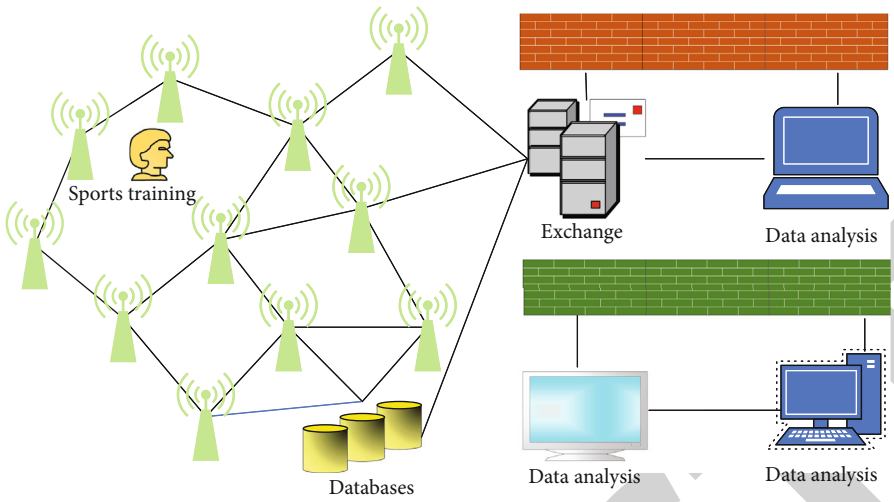

Figure 3: Schematic diagram of the system structure.

employing wireless communication. Nodes integrated with different types of sensors can be installed on athlete's body or movement path to collect relevant movement parameters. These parameters are sent to the base station through the RF module, which collects and processes the data through its internal management software and displays it in real time on an LCD screen. The motion data collected by the base station can be stored in the database system for a long time to provide a basis for comprehensive motion analysis and to construct an expert system by accumulating a large number of data of outstanding athletes.

The hardware structure of the sensor node mainly consists of the processor module, sensor module, RF module, and power module. The power supply module provides a stable and accurate energy source to the whole node and is a prerequisite for the node to work. The node requires a voltage range of 2.6~3.6 VDC and is designed to be powered by 2 AA batteries. Under the wireless sensor network, for this system design, it is ensured that the data obtained by each sensor node can be combined to improve the efficiency of the system sensor network. Under wireless sensor network, the sports training system is designed to ensure that the system design from the interface, information transfer, network status, and user privacy security can get the most basic guarantee to improve the system design security. For sports training management, ensure that the system can have a sports manager mindset, can objectively follow the laws of sports training, based on wireless sensor network technology, and constantly improve the efficacy of sports training, planning, organization, control, coordination, and innovative management of sports training process [25, 26]. At the same time, in the system design, ensure that the sports training management system can meet the needs of sports training managers and sports training management objects, optimize and improve the system information dissemination and storage work, ensure that the system can be used to measure sports training indicators, and improve the practicality of the system so that the system design meets the needs of users.

3.2. Sports Training Human Data Analysis. The physical test data collection, by the IoT front-end data collection measurement accuracy and error and other objective factors, will lead to some data measurement inaccuracy, or even serious deviation from the normal situation, and then generate data outliers. The appearance of outliers will not only affect the performance query work but also, if the original data is mined, reduce the reliability of the results, and even not mining the law or mining the wrong law, so it is necessary to screen the original data through outlier detection. Since there are large differences in physical fitness among individuals, if we directly check the excellent rate and passing rate according to the whole grade, we cannot know the details of the changes in performance, so this paper chooses to check what kind of changes everyone has made based on their original performance and calculates their proportion in the whole when analyzing the overall physical fitness trend of students in the whole school. Physical fitness interventions are physical education teachers who develop sports training programs to help improve students' physical fitness test scores based on their performance [27–29]. As training venues, times and environments vary from subject to subject. Suggestions are provided, while the association between subjects is explored and further validated by the Pearson correlation coefficient. After obtaining the correlations among subjects, when it is not possible to train specifically for a certain subject due to the limitation of teaching time and teaching space, it is possible to train for subjects with stronger correlations and less demanding teaching space and time, thus improving the performance against the aforementioned poorer subjects, which helps develop physical education teaching plans and improve the efficiency of physical education teaching and performance improvement.

The fall detection system can be functionally analyzed and divided into two main modules: fall detection and remote alarm. Fall detection mainly requires collecting information from sensor data, processing the data, extracting data feature vectors, and recognizing the motion. If yes, end this recognition; otherwise, continue to extract the peak

value, trough value, standard deviation, and covariance of the synthetic acceleration amplitude value in the current window, and use the second-level decision tree for further recognition to accurately identify whether there are abnormalities such as falls the action occur. The remote alarm is a voice and light alarm when the system detects a fall and uploads the fall status to the cell phone via Bluetooth communication for corresponding alarm processing. These functions require the collaboration of various parts of hardware modules to complete. The processor in the wearable device is generally selected for specific purposes and requirements. The processor chip selected in this study needs to meet the requirements of hardware resources in the system, such as the SPI port of the hardware, the serial input port of the periphery, and the speed of processing data and requires low energy consumption in the system for portability. The STM8S003F of the STM8S series is used for this system, considering the above factors and the complexity of the design implementation. STM8S controllers are the product of consumer electronics development and industrial control applications and are now mainly used in various fields such as the automotive industry, industrial control equipment, electrical equipment, and the medical care industry.

After the microcontroller acquires the signal from the sensor, it needs to have an agreed data format for the processor to parse out the acceleration data and angular velocity data from the received data packets without errors. In this system, there are 2 data packets for each frame of sensor data collected, which are the data packet of the acceleration sensor and the data packet of angular velocity sensor output in order, where the time interval is 50 ms to output one frame of data. The data format of the acceleration packet transmission is shown in Figure 4.

First, extract the peak, trough, and standard deviation of the magnitude of the synthetic angular velocity in a window, and use the first level decision tree to identify whether there is an abnormal action; if so, end this identification; otherwise, continue to extract the peak, trough, standard deviation, and covariance of the magnitude of the synthetic acceleration in the current window, use the second level decision tree for further identification, and accurately identify whether there is an abnormal action such as falling. The second layer decision tree is used to further identify whether abnormal movements such as falls occur. The sensor nodes in the wireless sensor network can realize not only the transmission of local data but also the transmission of data from the neighboring nodes of the wireless network, which has the function of double wireless propagation. Moreover, the process of wireless sensor network design should be able to be controlled based on the background management software to collect the node data in the sensor network and transmit the data to the sports training system through the router.

The main purpose of wireless communication is not only to achieve control information, collection information, and energy detection information transmission of sports training, using wireless radio frequency to achieve the reception of the transmitter module, but also able to send its information to other nodes, to achieve the disassembly of the function of the wireless communication module.

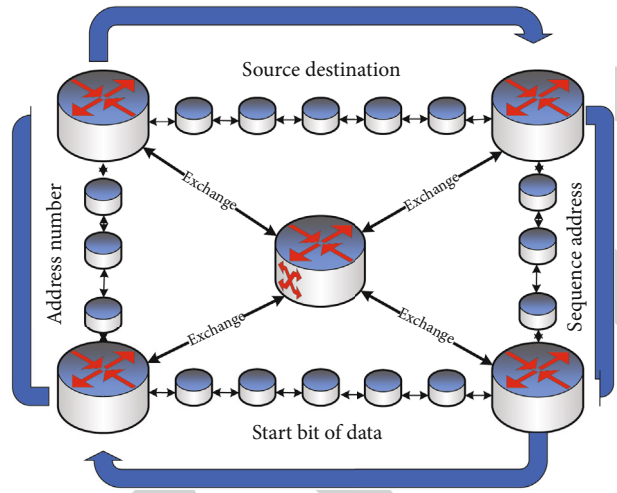

Figure 4: Schematic diagram of the packet format for acceleration.

In the process of realizing the design of a sports training system, the node hardware in the wireless sensor network mainly consists of wireless transmission and information processing units. The main purpose of the processing unit can achieve the control of the operating sensor nodes, the system data storage issues to deal with, for which the sensor collection unit can realize the effective responsibility of the system management area and realize the collection of sports information, and wireless sensing can also realize wireless node information communication, to ensure that this system can realize sports training (as shown in Figure 5).

The functional modules in the sports database management system mainly include data collection, system configuration, network monitoring, and data management. The system configuration parameters mainly include the configuration of a user, database connection, and system parameters, such as the sports personnel number, test mode, and the number of test nodes, to meet the needs of different training and testing. The data collection belongs to the core of the database management system [30, 31]. The database center and the base station are connected via USB interface, and after ensuring the connection request from the base station, the data will be analyzed with a customized packet protocol, and then, the database will be stored in the order of data collection and the sports personnel number [32, 33]. The network detection module can fully demonstrate the monitoring role of the management system of the motion database in the wireless sensor network, such as realizing the status of the wireless sensor network nodes.

4. Simulation Results and Analysis

4.1. Static Action and Dynamic Action Comparison Results. We can make an intuitive judgment of the motion state based on the measured data. In this system, the collected motion states include "walking," "jumping," "standing," "sitting," and "lying". "Lying" and other five kinds of movement can be divided into "dynamic action" and "static action". A simple classifier can be used to distinguish between the two types of movements (as shown in Figure 6). The x-axis angle

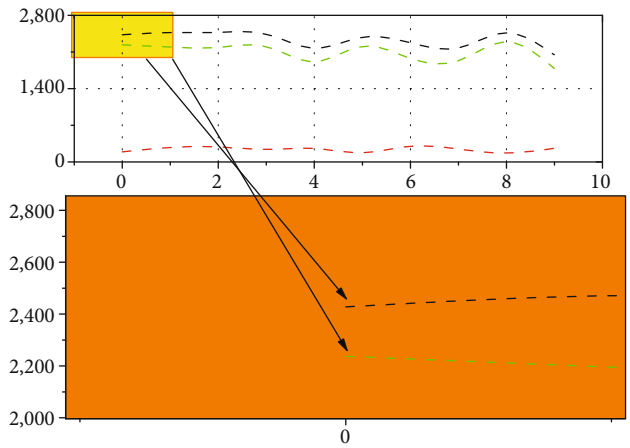

Figure 5: Resulting data of communication experiment statistics.

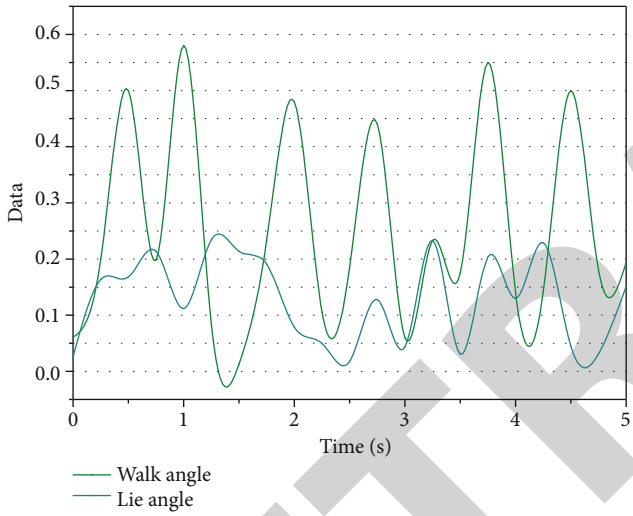

Figure 6: Comparison of x-axis angular data.

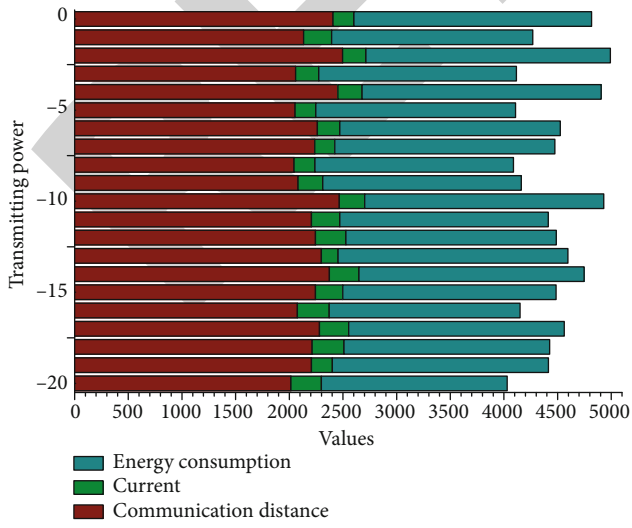

Figure 7: Current consumption of the node at different transmitting powers.

data of "walking" and "lying" can be seen that the motion posture of "walking" has high frequency and large amplitude, while the motion posture of "lying" has low frequency and small amplitude. There is a clear difference between "walking" motion posture with high frequency and large amplitude and "lying" motion posture with low frequency and small amplitude.

The static motion data obtained from the test varies greatly among testers and cannot be judged intuitively based on a single pose data from a single sensor. To better classify the motion gestures or to improve the accuracy of motion gesture recognition, it is necessary to specify testers' movements during the test, so that they are "motionless" during the test, or to improve the accuracy of the gesture sensors, or to apply more accurate classification algorithms to improve the static motion classification. In comparison, the third option is more reasonable.

The data collision rate and packet loss rate, current consumption, and power consumption of wireless communication between the nodes of this system are tested in the experiment. The current consumption of the nodes at different transmitting power and power consumption at different operating modes are also measured as shown in Figure 7.

From the above experimental results, we can see that the false alarm rate (which refers to the false reporting of normal daily behavior as falls) is 6.5%, and the missed alarm rate (which refers to the false reporting of falls as normal behavior) is 5%; the highest false alarm rate is the most vigorous movement of squatting and standing up, but the probability of this type of movement in the daily life of the elderly is not very high. The underreporting rate for falls is relatively low. The impact of missed alarms in the life of the elderly is much greater than false alarms, which can lead to unpredictable dangers after a fall, and false alarms can be canceled by directly turning off the switch to cancel the remote alarm. Therefore, the system in this study should also follow this principle. Overall, the fall system in this study meets the objectives and requirements of the system in the needs.

4.2. Results of Data Collection and Analysis. The first analysis of the data mining results for male students at the support level of 0.2 and confidence level of 0.8; among the 49 strong rules mined for male students, 38 of them were found to be failing the pull-ups, while the other 11 were found to be passing the 50-meter run, with no other strong rules. Most people passed the 50-meter run, normal weight, and sit-ups. From this, we can see that the distribution of physical fitness test scores is approximately normal, so if the support degree is set high, the mined results are not valuable, but only reflect some common patterns of college students' physical fitness test scores.

Therefore, the support was adjusted downward, and the scale of the strong rules obtained at this time was greatly improved. First, the data of the boys were mined, and some of their results are shown in Figure 8.

From Figure 8, it can be obtained that for boys, among those with good overall assessment scores, the proportion of those with normal weight, excellent 50-meter run, and

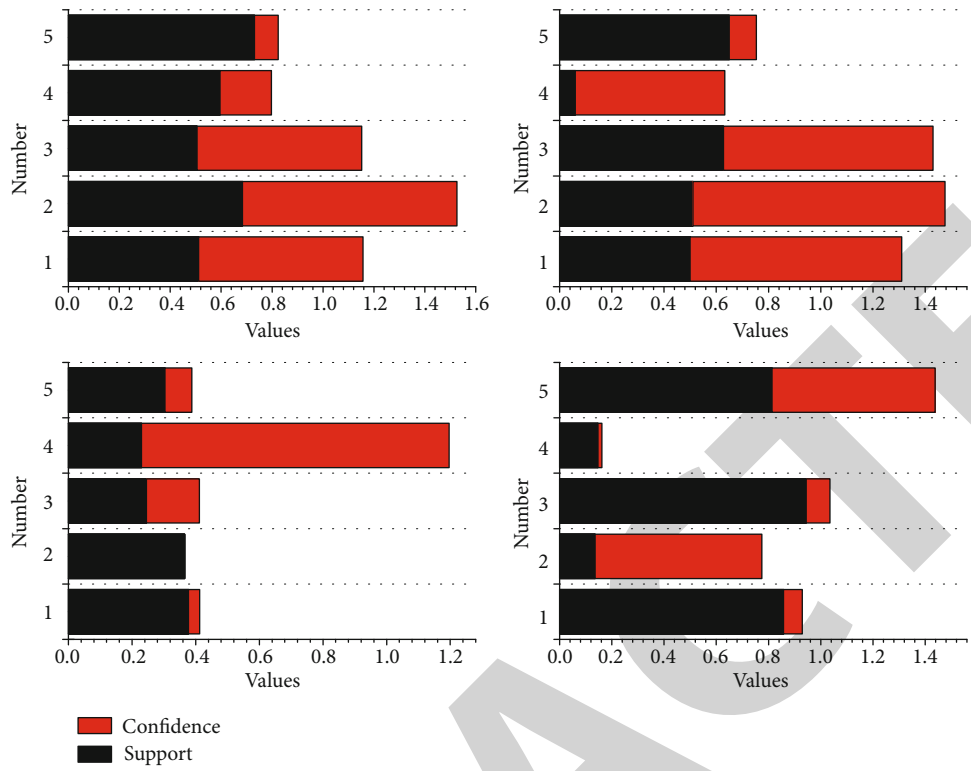

Figure 8: Rule results.

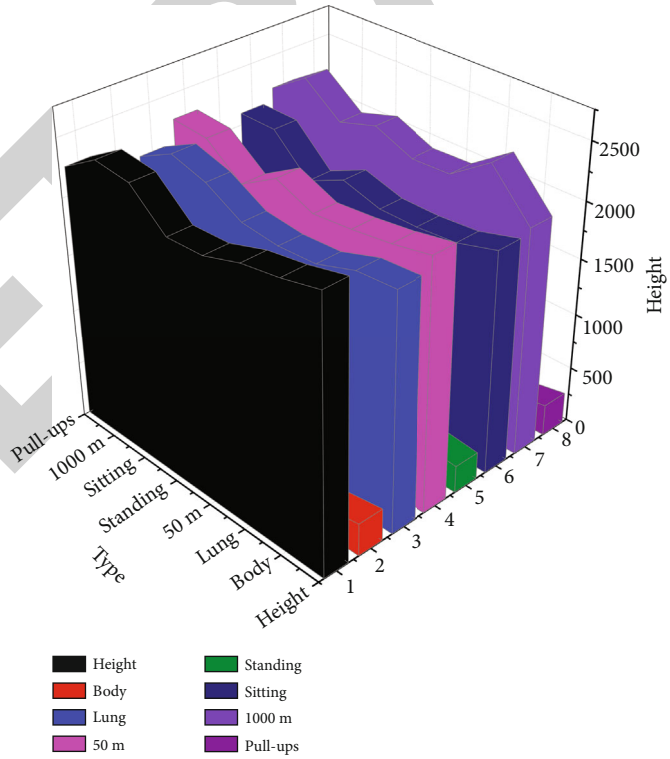

Figure 9: Correlation coefficient analysis.

excellent standing long jump is large, but the strong rule does not hold if it is inverted, which indicates that the influence of any single subject score on the overall assessment score is not decisive, but the influence factors of the 50-meter run, weight, and standing long jump are large. The proportion of normal weight is 94.7%, the proportion of

50-meter running is excellent and good is 85.8%, the proportion of standing long jump is excellent and good is 76.4%, and the proportion of excellent and good in other subjects is less than 60%. Therefore, if you want to improve the overall evaluation results, you can focus on practicing the 50-meter run and standing long jump in physical education. To verify this conclusion, a database search was conducted, and it was found that among the boys with good overall assessment scores, the percentage of those with normal weight was 94.7%, the percentage of those with the excellent 50-meter run was 85.8%, and the percentage of those with the excellent standing long jump was 76.4%, while the percentage of those with excellence in all other subjects was less than 60%. Therefore, if we want to improve the overall assessment, we can focus on practicing a 50-meter run and standing long jump in physical education and at the same time control the weight, so that the possibility of students achieving excellent overall assessment is also the greatest. For female students, the proportion related to their overall assessment scores is shown in Figure 9. In Figure 9, the number generation represents the sorting of types, which has no special meaning here.

The results confirm that the use of wireless sensor network technology in the design of sports training systems improves the performance of the system application by 16% and improves the interactivity of the sports training system in practice by 8%. The existing human motion recognition systems are mainly vision-based and sensor-based. Although the recognition success rate and algorithm complexity of vision-based recognition systems are more ideal, they are more dependent on the external environment and are more suitable for indoor systems. And with the rapid development of wireless body area networks, the sensor-based human motion recognition system has recently been widely used and developed in many aspects because of its advantages of easy portability and less dependence on the environment. However, there are some urgent problems in sensor-based human motion, such as how to extract effective feature values in human motion recognition and how to design efficient identifiers that can be moved to portable terminals. The human motion recognition system based on skeletal points can collect human motion information as well as classify the data from inertial measurement units directly through algorithms to obtain the human motion status. The system is of great help to the research and expansion of human-computer interaction and can be useful for enhancing human-computer interaction through posture recognition, combined with the Internet of Things technology, to develop a broad market.

5. Discussion

In this paper, a TinyOS-based central node and sensor node program is designed in C language to implement a star-type wireless sensor network using CSMA/CA protocol, and a sensor node with a temperature and humidity digital sensor SHT10 is designed for temperature and humidity data collection as an example. When the sampling period is 10 s and powered by a 60 mAh battery, the sensor node can work continuously for 52 days. The design meets the need for wireless, portable, and low-power acquisition of human physiological parameters. The use of nest, a modular programming language, improves development efficiency and facilitates expansion. The research and design methodology presented in this paper can be used in relevant applications.

6. Conclusion

This system applies wireless sensor network technology to athletes' sports training process and designs and develops a sports training system with good performance and low price. The use of wireless sensor network technology to design sports training systems significantly improves the performance of the system and not only well realize the automatic control of the training mode and process but also greatly support the training needs in various outdoor sports venues with flexible networking. Based on wireless sensor network technology, the design of sports training system and the system application test found that the use of the system can be more scientific and rational management of sports training work and play a positive application value. At the same time, the use of wireless sensor network technology in the design of sports training systems can improve the system application performance by 16.0% and can improve the interactivity of sports training system in practice by 8.0%. For the current sports training system design, the use of wireless sensor network technology can help to achieve real-time, remote, and safe sports training management, improve the system design performance and application quality, and better play the role of the system in sports training with a positive impact. It can be expected that the widespread use of wireless sensor networks is an inevitable trend, and its use in sports training will have very good prospects for application due to the advantages of new technology, low cost, ease to operate, good real-time, portable, and so on.

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.

Acknowledgments

This work was supported by the Henan University of Urban Construction.

References

[1] L. Wang, Y. Chen, Z. Zhao, L. Zhao, J. Li, and C. Li, "A multimodal health data fusion and analysis method based on body sensor network," *International Journal of Services Technology and Management*, vol. 25, no. 5/6, pp. 474–491, 2019.

[2] B. Yao and N. Liang, "A smart position optimization scheme for badminton doubles based on human–computer interactive training in wireless sensor networks," *EURASIP Journal on Wireless Communications and Networking*, vol. 2020, no. 1, Article ID 16, 2020.

[3] D. Zhang, J. Gao, X. Liu, T. Zhang, and D. X. Zhao, "Novel approach of distributed & adaptive trust metrics for MANET," *Wireless Networks*, vol. 25, no. 6, pp. 3587–3603, 2019.

[4] B. Abidi, A. Jilbab, and E. H. Mohamed, "Wireless body area networks: a comprehensive survey," *Journal of Medical Engineering & Technology*, vol. 44, no. 3, pp. 97–107, 2020.

[5] R. Punj and R. Kumar, "Technological aspects of WBANs for health monitoring: a comprehensive review," *Wireless Networks*, vol. 25, no. 3, pp. 1125–1157, 2019.

[6] M. Kaur and L. Singh, "A survey on mobile sensing technology and its platform," *International Journal of Advanced Networking and Applications*, vol. 9, no. 4, pp. 3523–3536, 2018.

[7] D. Biswas, L. Everson, M. Liu et al., "CorNET: deep learning framework for PPG-based heart rate estimation and biometric identification in ambulant environment," *IEEE Transactions on Biomedical Circuits and Systems*, vol. 13, no. 2, pp. 282–291, 2019.

[8] D. Zhang, T. Zhang, J. Zhang, Y. Dong, and X. D. Zhang, "A kind of effective data aggregating method based on compressive sensing for wireless sensor network," *EURASIP Journal on Wireless Communications and Networking*, vol. 2018, no. 1, Article ID 15, 2018.

[9] D. Olivia, A. Nayak, and M. Balachandra, "QoS aware routing in body-to-body network for emergency medical care: issues and challenges," *International Journal of Wireless and Mobile Computing*, vol. 17, no. 2, pp. 115–127, 2019.

[10] N. Belapurkar, J. Harbour, S. Shelke, and B. Aksanli, "Building data-aware and energy-efficient smart spaces," *IEEE Internet of Things Journal*, vol. 5, no. 6, pp. 4526–4537, 2018.

[11] S. Hara, H. Yomo, R. Miyamoto et al., "Challenges in real-time vital signs monitoring for persons during exercises," *International Journal of Wireless Information Networks*, vol. 24, no. 2, pp. 91–108, 2017.

[12] P. H. Soares, J. P. Monteiro, H. F. Freitas, R. Zenko Sakiyama, and C. M. Andrade, "Platform for monitoring and analysis of air quality in environments with large circulation of people," *Environmental Progress & Sustainable Energy*, vol. 37, no. 6, pp. 2050–2057, 2018.

[13] G. S. Karthick and P. B. Pankajavalli, "A review on human healthcare Internet of Things: a technical perspective," *SN Computer Science*, vol. 1, no. 4, pp. 1–19, 2020.

[14] S. SriGowthem, "Current progress on passion efficient cluster based routing protocols of wireless sensor networks for medicine systems," *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, vol. 12, no. 1S, pp. 561–566, 2021.

[15] S. M. Shimly, D. B. Smith, and S. Movassaghi, "Experimental analysis of cross-layer optimization for distributed wireless body-to-body networks," *IEEE Sensors Journal*, vol. 19, no. 24, pp. 12494–12509, 2019.

[16] M. Mayer and A. J. Baeumner, "A megatrend challenging analytical chemistry: biosensor and chemosensor concepts ready for the internet of things," *Chemical Reviews*, vol. 119, no. 13, pp. 7996–8027, 2019.

[17] M. Mohammed Mustafa and V. Parthasarathy, "A clustering TDMA and code block binding algorithms to enhance the node energy and security of the network," *Wireless Personal Communications*, vol. 116, no. 1, pp. 767–775, 2021.

[18] S. Tabatabaei, "A novel fault tolerance energy-aware clustering method via social spider optimization (SSO) and fuzzy logic and mobile sink in wireless sensor networks (WSNs)," *Computer Systems Science and Engineering*, vol. 35, no. 6, pp. 477–494, 2020.

[19] M. C. Chen, S. Q. Lu, and Q. L. Liu, "Uniqueness of weak solutions to a Keller-Segel-Navier-Stokes model with a logistic source," *Applications of Mathematics*, vol. 121, 2021.

[20] M. Tong, Y. Tao, Y. Zhang, K. Bian, and W. Yan, "Trajectory-based user encounter prediction over wireless sensor networks," *Wireless Personal Communications*, vol. 107, no. 4, pp. 1933–1949, 2019.

[21] D. R. Tisna, M. U. H. Al Rasyid, and S. Sukaridhoto, "Implementation of oxymetry sensors for cardiovascular load monitoring when physical exercise," *EMITTER International Journal of Engineering Technology*, vol. 8, no. 1, pp. 178–199, 2020.

[22] M. Chowdhury, "Time and energy-efficient hybrid job scheduling scheme for mobile cloud computing empowered wireless sensor networks," *International Journal of Ad Hoc and Ubiquitous Computing*, vol. 37, no. 1, p. 26, 2021.

[23] D. G. Zhang, L. Chen, J. Zhang et al., "A multi-path routing protocol based on link lifetime and energy consumption prediction for mobile edge computing," *IEEE Access*, vol. 8, no. 1, pp. 69058–69071, 2020.

[24] L. Cheklat, M. Amad, and A. Boukerram, "Wireless sensor networks, state of art and recent challenges: a survey," *Sensor Letters*, vol. 15, no. 9, pp. 697–719, 2017.

[25] M. C. Chen, S. Q. Lu, and Q. L. Liu, "Uniqueness of weak solutions to a Keller-Segel-Navier-Stokes system," *Applied Mathematics Letters*, vol. 121, pp. 107417–107417, 2021.

[26] D. U. Maheswari, S. Sudha, and M. Meenalochani, "Fuzzy based adaptive clustering to improve the lifetime of wireless sensor network," *China Communications*, vol. 16, no. 12, pp. 56–71, 2019.

[27] J. Yan, Y. Meng, X. Yang, X. Luo, and X. Guan, "Privacy-preserving localization for underwater sensor networks via deep reinforcement learning," *IEEE Transactions on Information Forensics and Security*, vol. 16, pp. 1880–1895, 2021.

[28] L. Ding, L. Huang, S. Li et al., "Definition and application of variable resistance coefficient for wheeled mobile robots on deformable terrain," *IEEE Transactions on Robotics*, vol. 36, no. 3, pp. 894–909, 2020.

[29] D. Zhang, X. Wang, X. Song, and D. Zhao, "A novel approach to mapped correlation of ID for RFID anti-collision," *IEEE Transactions on Services Computing*, vol. 7, no. 4, pp. 741–748, 2014.

[30] D. Vinodha, E. Anita, and D. M. Geetha, "A novel multi functional multi parameter concealed cluster based data aggregation scheme for wireless sensor networks (NMFMP-CDA)," *Wireless Networks*, vol. 27, no. 11, pp. 1–18, 2021.

[31] X. Liu, D. Zhang, T. Zhang, Y. Cui, L. Chen, and S. Liu, "Novel best path selection approach based on hybrid improved A∗ algorithm and reinforcement learning," *Applied Intelligence*, pp. 1–15, 2021.

[32] N. M. Raj, D. Bhattacharyya, D. Midhunchakkaravarthy, and T. H. Kim, "Multi-hop in clustering with mobility protocol to save the energy utilization in wireless sensor networks," *Wireless Personal Communications*, vol. 117, no. 9, pp. 1–15, 2021.

[33] W. Wang, F. Xia, H. Nie et al., "Vehicle trajectory clustering based on dynamic representation learning of internet of vehicles," *IEEE Transactions on Intelligent Transportation Systems*, vol. 22, no. 6, pp. 3567–3576, 2021.