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Design and Data Analysis of Sports Information Acquisition System Based on Internet of Medical Things

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ABSTRACT The Internet of medical things is an emerging information network technology, which can realize the automatic identification, monitoring and management of personnel, medical equipment, medicines, etc. through this network, and is an effective means to reduce medical errors and improve work efficiency. This article first studies the theory and method of health information and sports information collection, that is, the temperature sensor and the acceleration sensor are used to collect human body temperature and exercise steps, respectively, and then estimate the human health and sports. Second, the prototype system of health and sports information collection system is realized the system is divided into two parts: terminal node and client information management system. Finally, a component collaborative modeling and data analysis method for Internet of medical things is proposed. This method constructs different types of components according to different functions of the Internet of Things equipment, and designs a set of communication mechanisms between the components based on the Internet of Things network communication characteristics, and uses visual methods to model. The experimental results verify that the method of collecting and analyzing human motion information using a motion information collection system is feasible. Multiple methods should be integrated to obtain as much information as possible to make the human motion analysis more scientific and reasonable.

INDEX TERMS Internet of medical things, motion information collection, collaborative modeling, data analysis, prototype.

I. INTRODUCTION

Internet of medical things is an effective technical means to realize intelligent identification, positioning, tracking, monitoring and management of patients and medical equipment, reduce medical errors and improve work efficiency. In the Internet of medical things, both physical and virtual medical objects have specific identities and physical attributes. They are seamlessly integrated into the information network through intelligent interfaces, and then use RFID, infrared sensors, GPS, laser scanners and other sensing devices. According to the agreed agreement, to realize automatic

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identification and monitoring of medical objects [1], [2]. At present, many researchers have carried out research on the architecture of the Internet of Things, and have proposed architectures such as autonomous architecture [3], [4], article web architecture [5]. In the Internet of medical things, due to the huge amount of data collected, on the one hand, the effective collection and integration of medical information has been achieved, making health promotion possible, and on the other hand, massive multi-source heterogeneous data in the network has inevitably appeared Integration and data sharing [6], [7]. In the network, it is necessary to process all kinds of collected information, including data, images, audio, text data, etc. After intelligently processing the collected information, real-time health file information resources are

obtained, and according to Corresponding real-time monitoring data, make personal health promotion reports, and carry out various forms of follow-up intervention. These make the information in the collection of motion information from the collection, processing to application [8], [9] have shown significant multi-source heterogeneous characteristics. Information transmission is data-centric. Because the number of sensor nodes is large and randomly distributed, the data obtained by monitoring the same event between adjacent sensor nodes is similar, but the sensor nodes have limited storage space and energy. Because of the dense distribution of large-scale sensor nodes, most of the collected data is redundant, which will shorten the lifetime of the entire network and reduce the efficiency of information integration [10]. At the same time, the network involves a large amount of health data spatial distribution, medical information, medical examination data, health measurement evaluation, equipment operation, and parameters. The spatio-temporal data of these dispersed systems is scattered in a heterogeneous system, which is based on different Data specification format and data analysis method [11], [12].

There are many technical researches on medical IoT abroad, including key technologies, sensor information fusion, time synchronization and positioning, and low power design [13], [14]. Many universities have carried out research on the direction of data fusion. According to whether data fusion is based on the semantics of application data, data fusion technology can be divided into the following three categories: application-independent data fusion technology [15], depending on Applied data fusion technology [16], and data fusion technology combining the above two technologies [17], [18]. In addition, foreign countries have also studied the design method of combining data fusion technology and routing technology, And the design method of constructing data fusion tree, etc., which can improve the efficiency of data fusion and show the status of data fusion technology. Currently, there are three sub-optimal solutions for the construction of data fusion tree: CNS; SPT.GIT and routing technology The data fusion includes fusion based on query method [19], [20], fusion based on link routing technology, fusion based on hierarchical routing technology, fusion based on secure routing technology [21], [22]. Data fusion based on query mode Technology is currently a relatively common research method for data fusion technology abroad. For example, the Cougar system studied in literature [23], [24] is based on the query mode. Data fusion technology has made many contributions. Both database systems use data fusion technology to reduce communication loss and improve data reliability. These are two main research results based on database query. Discuss the continuous computing fusion on the network Due to the impact of performance, a tree structure establishment algorithm is proposed, which can perform high energy efficiency calculations for partial fusion functions [25], [26]. Experiments show that the algorithm can produce high accuracy by discarding high packet loss rate and asymmetric

links [27], [28]. By discussing the time series model of data fusion in sensor networks, aiming at the problem of periodic data fusion, compare the performance differences of different fusion methods [29], [30]. Studies have shown that setting the timing according to the position of the nodes in the fusion tree can achieve a more ideal effect, achieve lower energy consumption, and maintain high accuracy and freshness [31], [32]. Modern sports biomechanical measurement technology marked by measurement and synchronous measurement technology has made human body movement measurement real-time, visualization and measurement analysis in three-dimensional space [33], [34]. Although modern measurement technology provides a powerful catalyst for the development of sports biomechanics, we should realize that the study of the mechanics of biological motion depends fundamentally on measurement research technology and analysis technology. Researchers in academia have realized that the limitation of applying modern measurement technology to the analysis of human motion is due to insufficient understanding of the essence of human motion mechanics. The measurement technology of sports biomechanics also depends on the development of other disciplines, such as computer technology, electronic measurement technology, human physiology and other related disciplines [35], [36]. In the field of orthopedics and rehabilitation, in order to evaluate disability, diagnose diseases and identify rehabilitation the objective and effective method is to perform gait analysis and function evaluation of other parts of the human body. Generally in the medical clinic, acceleration sensor measurement is used to assist in the diagnosis of patients with leg joints [37], [38], treatment research reports (including gait, sitting posture, posture, etc. of patients) Analysis, etc.). Because the measurement of physical quantities such as the movement state of limbs when the human body is walking can help us analyze the movement function of some parts of the human body (especially the joints), and thus provide a certain reference basis for medical rehabilitation. By selecting different human motion information to study the laws of human motion, there are many ways to measure human motion, not just limited to acceleration collection, but the collection of single motion information parameters has not been able to meet people's needs. Therefore, the method of judging human exercise intensity also needs to be improved. The evaluation and calculation of acceleration combined with human physiological indicators such as temperature and heart rate are the new entry point of human body research [39]–[41]. In summary, the progress of the information parameter collection system has been changed from the traditional The method has developed to the ubiquitous collection method today, that is, the comprehensive use of existing electronic technology and communication technology to detect various human health and sports indexes, thereby providing a scientific basis for human health assessment and sports calculation [42], [43]. The progress of the information parameter collection system has evolved from the traditional method to the ubiquitous collection method today, that is, the comprehensive use of existing electronic

technology and communication technology to detect various human health and exercise indexes at any time and anywhere, and then the calculation lacks scientific basis.

With the development of sports biomechanics, human anatomy, computer science and other related disciplines, it has further promoted the development of human sports research in a more scientific and deep direction. In-depth analysis of human motion, especially the relationship and characteristics of human motion and motion acceleration parameters, based on research and analysis of a large number of literature, the human body is regarded as a combination of various links connected by joints, and a human bar graph model is established; Through the establishment of the human motion coordinate system, the movement of each feature point of the limb is studied. At the same time, due to the huge amount of medical and health data collected in the Internet of medical things, the effective fusion of data is of great help to improve the transmission efficiency of the network and reduce the power consumption of the network. Therefore, it is of great significance to study the data fusion algorithm in the Internet of medical things. In this paper, through the research of current Internet of medical things data fusion technology, an event-driven data fusion tree routing algorithm is proposed for data analysis. Designed according to the characteristics of data in the Internet of medical things, based on the severity of the event, according to the corresponding thresholds and weights to divide dynamic clusters and build routing trees, and analyze the data fusion delay in the network. The algorithm has proved that its performance is better than the traditional algorithm through simulation and simulation experiments.

II. INTERNET OF MEDICAL THINGS SPORTS INFORMATION COLLECTION SYSTEM ARCHITECTURE

Compared with other IoT applications, the medical IoT has many features and complex applications. There are a large number of heterogeneous data, heterogeneous interfaces and heterogeneous protocol conversion in the system. In its system architecture, the terminal equipment for data collection and APs and gateways that ensure safe data access belong to the perception layer; middleware, network management software, and information collection, aggregation, analysis, and distribution software belong to the transmission layer; medical IoT application systems such as electronic medical records belong to the application Layer, the medical IoT system architecture is shown in Figure 1.

(1) Perception layer. The Internet of medical things perception layer collects data from patients and medical equipment objects through sensor devices, and then transmits data through short-distance transmission technologies such as Bluetooth and infrared to realize the unified recognition of item perception information and control information in medical activities. The perception layer mainly includes key technologies such as radio frequency technology, two-dimensional code tags and identifiers, smart cards, sensors, and medical data secure access to gateways. Among them,

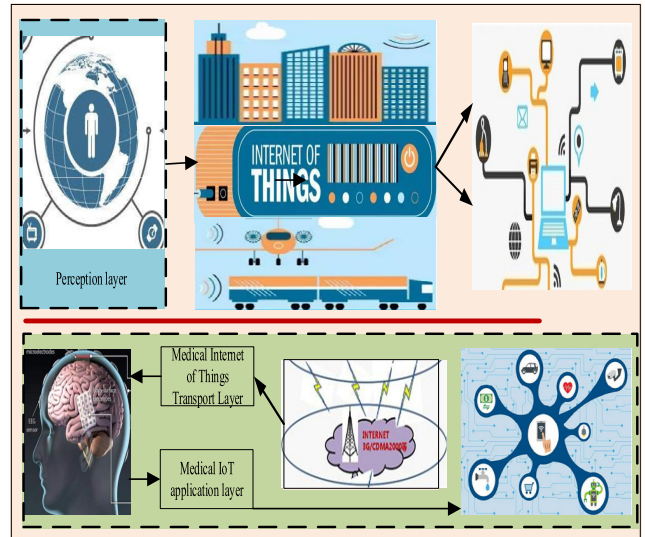


FIGURE 1. Internet of medical things sports information collection system architecture.

RFID is the core technology of the Internet of medical things. It is composed of electronic tags and readers. It is composed of a writer, which stores electronic data in a specific format to identify object information, and uses non-contact automatic identification technology to locate and track the attached object through the electronic tag. It has a long reading distance and fast data access speed., High security and other advantages.

(2) Transport layer. The transmission layer includes middleware, network management software and information collection, aggregation, analysis and release systems, etc., and establishes an interface with the electronic medical records, HIS, and LIS located in the medical IoT application layer. The transmission layer is mainly used to convert the various perception and control information identified by the perception layer into a standard format according to the general data transmission protocol, so as to realize the connection and intercommunication between people and things, things and things in the Internet of medical things.

(3) Application layer. The medical IoT application layer mainly completes the calculation, processing and knowledge mining of the data collected by the perception layer, and combines these data with various application systems in medical activities, such as various medical information systems and individuals.

A. HUMAN MOTION INFORMATION COLLECTION

The collection and analysis of human motion information refers to the use of some means to track and capture the motion of the human body, obtain some parameters of human motion, and analyze and process these parameters, so as to reconstruct the structure and posture of the human body [44] or perform other application. The motion information displayed by the human body during the exercise is mainly reflected in the body posture, joint angle, displacement of the

body and limbs, speed and acceleration, the magnitude and direction of the force, and the rate of change of the dynamic force. Measurement of this information and analysis using biokinematics technology can evaluate the state of the human body in motion. The process of human body motion analysis is mainly composed of motion tracking measurement, signal processing, and data analysis.

The movement of the human body is finally reflected by the changes in the posture and position of the limb in space. There is a certain relationship between the stored information such as acceleration, speed, displacement, posture, force, etc., as long as the acceleration information is obtained, other the parameter information can be obtained by integrating it. The following uses the measurement of human forearm motion information as an example to illustrate the application method of the acceleration sensor in the collection of human motion information. The human forearm always has a certain angular relationship with the vertical direction (or horizontal direction) during the movement. The motion posture of the human forearm can be detected by the angle between each axis of the three-axis acceleration sensor fixed on the forearm and the direction of gravity (vertically downward). Taking simple plane movement as an example, the elbow joint of the person to be tested does not move on the tabletop, the forearm makes a vertical plane elbow flexion around the elbow joint, and the acceleration sensor is installed on the wrist joint. Under the above constraints, when the forearm is not moving, it is only necessary to detect the angle between each sensitive axis of the current acceleration sensor and the direction of gravity to analyze the posture of the forearm. When the sensor remains relatively stationary, it will be affected by gravity, so that the acceleration sensor outputs an acceleration signal with the same magnitude and opposite to the direction of gravity acceleration. The output component of this acceleration signal on three axes depends on the three sensitive axes and the direction of gravity Angle.

$$\begin{cases} m_x = ml \cos \beta + m_0 \\ m_y = ml \cos \varphi + m_0 \\ m_z = ml \cos \chi + m_0 \end{cases} \quad (1)$$

In the formula: m_x, m_y, m_z represents the voltage signal output by the three axes of accelerometer X, Y, Z.

m represents the sensitivity of the accelerometer;

l represents the acceleration of gravity, generally 9.8m/s^2 ;

m_0 represents the voltage output by the accelerometer when the acceleration is 0.

The inverse function of the above formula can be obtained:

$$\begin{cases} \beta = \arccos \frac{m_x - m_0}{ml} \\ \varphi = \arccos \frac{m_y - m_0}{ml} \\ \chi = \arccos \frac{m_z - m_0}{ml} \end{cases} \quad (2)$$

Since the Y-axis and Z-axis of the sensor measure the components of gravity acceleration in their respective directions at rest, if the measured data is inversely calculated,

the combined values of the two measured in the direction of gravity should be equal to gravity Acceleration, if the result after synthesis is not equal to 1, it means that at least one of the axes has acceleration other than gravity. In this example, since the elbow joint is fixed and the arm length is constant, there is no displacement in the Y-axis direction. Therefore, when the accelerations measured in the Y-axis and Z-axis directions are vertical When the synthesis in the direction is not g , it can be inferred that the forearm is doing variable-speed movement; when the acceleration measured in the two directions of the Y-axis and the Z-axis in the vertical direction is equal to g , the forearm may be in static or uniform speed movement State, which depends on the previous state.

B. DESIGN OF HUMAN MOTION INFORMATION ACQUISITION SYSTEM BASED ON INTERNET OF MEDICAL THINGS

The motion information collection system uses the non-electrical electrical measurement method of human motion, and uses acceleration sensors to collect acceleration parameters during human motion. The system can obtain relevant information about limb movement in space, such as acceleration, by processing and analyzing the collected acceleration, Speed vector changes, limb displacement trajectory, spatial attitude and other information.

The slave of the signal acquisition unit completes the acquisition of acceleration signals and analog-to-digital conversion. The role of the master is to control the slave to synchronize the signal acquisition and summarize all the acquisition results of the slaves to upload to the data processing unit.

The signal acquisition unit slave CPU completes the corresponding tasks by receiving instructions from the host, which mainly includes the functions of starting signal acquisition, uploading collected data, and deleting data. When the slave receives the command to start the acquisition, it will perform AD conversion on the three-channel analog output from the accelerometer ADXL330 at a certain frequency, and temporarily store the result in the on-chip RAM. When the upload command from the host is received, Upload the data in the storage area to the host, the flow chart of the main program and interrupt service program of the slave is shown in Figure 2.

When the slave program is running, it only responds to the I2C interrupt request. When there is no interrupt signal, the slave collects and stores the analog output by the acceleration sensor at a fixed sampling frequency. When the host of the signal acquisition unit sends an I2C request, it starts from the machine responds to the interrupt and uploads data or other operations according to the command type of the host.

After the system completes the initialization work, the user can set related functions and parameters through the function buttons of the data processing unit. The system will save the current settings. If the function is not set, the system defaults to the last setting value. The main significance of the function

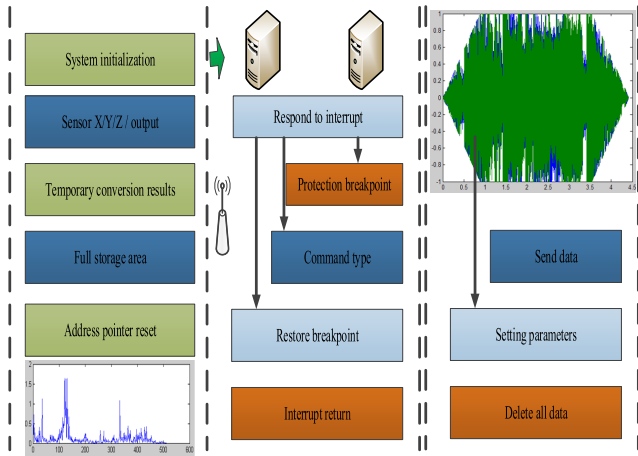


FIGURE 2. Flow chart of the slave software of the signal acquisition unit.

and parameter setting is that the acceleration sensor may be used in different occasions, such as movement standardization judgment, movement speed measurement, displacement measurement, etc., and the accuracy and algorithm will be different for different application occasions, so the function and Parameter setting. The main functions that can be set in the system include: (1) spatial displacement measurement; (2) movement normative training; (3) movement recognition. The system parameter setting is mainly for the sensitivity of the system.

The job of the data processing unit is to analyze and process the data collected by the acceleration sensor. Reading the data is the first step of data processing. The system can read in data in real time and batch in two ways according to the needs. Real-time read-in means that the signal collection unit uploads the current set of data to the data processing unit immediately after the A/D conversion is completed by the signal acquisition unit; while the batch read-in method is that the signal acquisition unit completes the current signal collection and After conversion, the results are temporarily stored until the data processing unit issues a read instruction, and then multiple sets of acceleration data are uploaded to the data processing unit.

The method used in this system is the limiting filtering method, that is, the two adjacent samples are subtracted, the increment (expressed in absolute value) is obtained, and then the maximum difference allowed by the two samples (by the acquisition The actual situation of the object is determined) $4Y$ is compared, if it is less than or equal to X , the current sampling value is taken; if it is greater than X , the last sampling value is still taken as the current sampling value. which is:

$$X = \begin{cases} X(K) & |X(K) - X(K - 1)| \leq X \\ X(K - 1) & |X(K) - X(K - 1)| > X \end{cases} \quad (3)$$

In different sports, the acceleration changes of the limb movements they monitor may be very different, and the acceleration and the rate of change of acceleration during

movement are different at different test points of the limbs, so when the acceleration sensor is on the body When the installation position is different, the value of X also changes. For example, when a person swings his arm, the curve of the acceleration of the elbow joint and the wrist joint is different. Therefore, the value of X is obtained based on a large number of experiments, and can be input through the keyboard when the system function is set. The data obtained by the data processing unit from the data acquisition unit is a 2-dimensional array composed of changes in multiple acceleration values. It is assumed that 5 sensor nodes are installed on the human arm, and each sensor outputs 3 channels of analog data. Collect 20 points of volume data, you will get an array of 15 rows and 20 columns.

C. DATA ANALYSIS AND PROCESSING

(1) The spatial displacement measurement function is mainly to measure the spatial displacement of an acceleration of the signal acquisition unit. Since each row of elements in the two-dimensional array represents the change of the acceleration value of the detected point in a certain direction, it is time The integral of the point can be used to obtain the speed change of the point, and then the speed is integrated to obtain the displacement of the point in a certain direction, and the displacement of the point in three directions is vector synthesized to obtain the displacement in space can also be calculated according to the position before the movement, after the movement of the detection point.

(2) The movement standard training function is mainly used in sports training, movement control and other occasions. The process is to collect the acceleration changes of the relevant test points when the person makes the movement and compare it with the acceleration change curve of the standardized movement. When the two reach a certain degree of closeness, the action can be considered to reach the norm. The movement normative training includes two processes. The first is to input the movement information, that is, the modeler makes the standardized movement. The system collects the acceleration information of the movement and stores it to generate the movement information database; after the movement information database is completed, then The trainee makes the same action, and the system collects the acceleration signals and matches them to determine the type of the action or the closeness of the action and the standard action by comparison.

The software compares the collected data with the database through data retrieval, and then performs relevant processing after obtaining the corresponding matching data. In this system, the data retrieval adopts a fast retrieval method based on space-time features. A spatial histogram model based on spatiotemporal features can be used to quickly retrieve motions similar to short query examples from unsegmented long motion sequences. The spatial histogram model mentioned in this article is the frequency distribution of the key space of the window. The frequency distribution is to classify the key space in the three-dimensional space-time feature,

and calculate the number of occurrences of each key space as the quantization code, and then obtain the quantization code book through the Linde-Buzo-Cray algorithm to reflect the distribution density of the key space, That is to say, the code numbers of those areas with densely spaced key are larger. In this way, the spatial histogram T is defined as follows:

$$T = (T_1, T_2 \dots T_L) \tag{4}$$

Here L is the number of blocks in the histogram, and T_1 is the number of key spaces classified into the first quantization code in the observation window. As mentioned above, a typical window length is the length of the query signal. The similarity of the spatial histogram of the query signal and the stored signal in the window can be obtained by the method of histogram intersection, defined as follows:

$$R(T_Q, T_R) = \frac{1}{D} \sum_{i=1}^L \min(T_Q, T_R) \tag{5}$$

Here T_Q, T_R is the query example and the spatial histogram of the stored data and D is the length of the window. In order to determine the judgment standard of similarity, it is essential to establish a model for the distribution of similarity. However, without some simplified and idealized assumptions, it is very difficult to obtain a similarity distribution. Therefore, our distribution model is based on an empirical basis.

For the integration of similarity, the range of the similarity of the sub-windows in the search and query example through the search exceeds a given threshold, and the similarity S for the entire window is defined as follows:

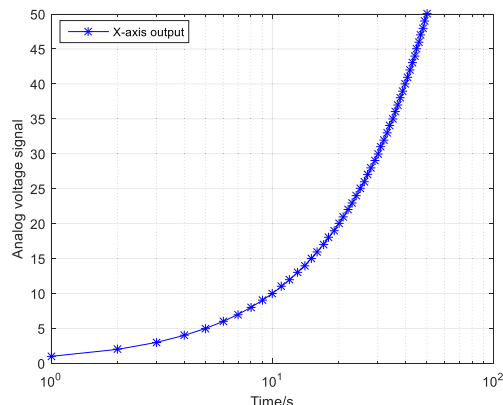
$$S = \min(S_j) \tag{6}$$

Here S_j is the similarity of the J-th sub-window. Now the problem can be reduced to finding the area where S exceeds the threshold. This can be done by calculating S_j sequentially. Let ω_j be the moving width of the J-th child window. When the original window is at the current position, the moving width of the original window is as follows:

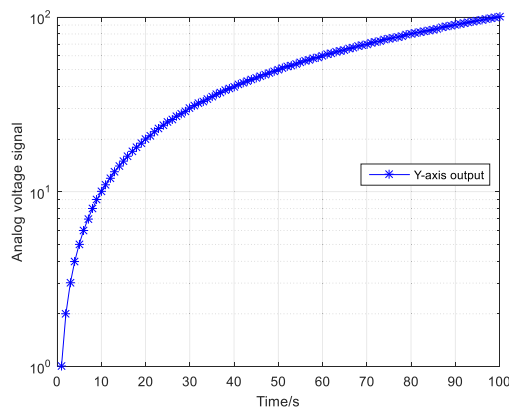
$$\omega = MAX(\omega_j) \tag{7}$$

(3) The function of motion recognition is mainly to analyze the acceleration signal collected by the acceleration sensor and restore the movement process of the human body. The accelerometers used in the signal acquisition unit must be installed at a fixed position on the human body, and when analyzing the data, due to the different body parameters of different testers, the acceleration data obtained when performing the same action will also be Differences occur, for example, the length of a person’s arm is different, and the linear acceleration of the wrist joint is naturally different when performing a swinging motion.

In terms of program algorithm, the above data matching method can still be used for relatively standard motion recognition, but there are many joints of human limbs, and the number of motion combinations of each joint in three degrees of freedom is countless, and it is impossible to list them one



(a) X axis motion output value change



(b) Y axis motion output value change

FIGURE 3. Acceleration sensor output voltage signal.

by one in the database. This requires analyzing the acceleration data according to different human body parameters and human body motion models. In the process of data analysis, the data generated by each accelerometer installed on the human body will be analyzed and calculated to obtain its spatial motion trajectory and spatial posture. The program will integrate the motion trajectory and posture of multiple test points and other information, combined with human body motion the model and the constraint relationship of each joint and link deduces human movement.

Figure.3 shows the changes of three analog voltage outputs within 100 seconds after the punching movement starts from 0 seconds to the end of punching. It can be seen from the figure that when the subject makes a punching movement along the x-axis direction, the characteristics of the output values of the two-axis acceleration sensors in the x and y directions. The ordinate in the figure is the analog voltage signal output by the acceleration sensor. This figure reflects the output changes of the acceleration sensor before and after the action, and during the action. The output of the sensor at static is mainly the decomposition of the acceleration of gravity in two directions, and the output of the dynamic process can reflect its movement process. Through a comprehensive analysis of the dynamic and static processes, the movement process and posture changes can be obtained.

TABLE 1. Digital filter algorithm verification data

Serial number	1	2	3	4	5	6	7	8	9	10
Raw data	125	135	148	145	146	155	145	145	135	135
Processed data	125	135	135	145	146	155	155	146	136	138
Serial number	10	11	12	13	14	15	16	17	18	19
Raw data	130	125	116	115	105	105	95	108	115	125
Processed data	130	125	116	116	105	105	95	95	118	125

After the data processing unit completes the analysis of the data, it will draw relevant conclusions, such as the result of action recognition, whether the action conforms to the specification, and the restoration of the action. The database is matched, and then the corresponding sound and light information is output through its display output circuit, and the application of action recovery is output to the PC through the serial communication interface or USB output interface, and the PC completes the functions of action recovery and reproduction.

In this system, the digital filtering of the data processing unit adopts the method of limiting filtering. APC is used to send a set of 8-bit data representing the acceleration data of the X axis of the No. 1 slave through the serial interface instead of the signal acquisition unit. The button of the unit sets the maximum deviation value of the adjacent data. In a group of data sent by the PC, the change value of some data is randomly exceeded the set value. After receiving the group of data, the data processing unit will filter the data according to the algorithm Processing, the processing result is returned to the PC, as shown in Table 1 is a set of data in the debugging process, the italic data in the processed data row in the table indicates that the data has been filtered.

First, set the function of the data processing unit of the system, set it to the data matching mode through the external button, and enter the motion training state. Use the serial port analog signal acquisition unit of the PC to transfer several sets of data to the data processing unit as standard action inputs. The data of these standard actions will be stored in the external expansion memory of the data processing unit in a certain order, and each input actions. After completing the action training process, the system automatically performs the action recognition state and sends a set of data to the data processing unit using a PC. The system will compare the received data with the data stored in the database during the training process according to a predetermined method. 3. Matching, and finally transfer the matching result to the PC through the serial interface. After many debugging, since the computer simulation input data does not have external interference, its accurate recognition rate can reach 100%. When adding random interference factors to the input data, its recognition rate is reach 95%.

In order to facilitate debugging, an analog voltage of 0-3 V generated by a stable DC power supply is input to the signal conditioning circuit of the signal acquisition unit,

and the serial port of the data processing unit is connected to the PC. Since the online debugging mainly solves the problem of wireless communication, the data processing unit does not process the data sent by the collection unit during debugging, and directly sends it to the PC for display to verify the reliability of wireless communication. By changing the output voltage of the regulated power supply, the data displayed by the data processing unit sent to the PC is shown in Table 2.

III. DATA ANALYSIS OF MEDICAL IOT

A. EVENT-DRIVEN CLUSTER TREE DATA FUSION ANALYSIS AND CONSTRUCTION ALGORITHM

The algorithm uses a cluster-tree combined topology structure, clusters the network according to the multi-hop mode dynamic clustering algorithm, and then constructs the data fusion subtree within the cluster from the current cluster head, and finally combines these fusion subtrees according to The connection costs are connected to form a complete data fusion tree, so that data can be transmitted along the fusion tree, which can improve the accuracy of the data and save the energy consumption of network nodes. Finally, according to the minimum fusion latency, a minimum fusion delay method is proposed.

When an emergency occurs in the network, some nodes in the monitoring area of the network configuration are stimulated by certain intensity, and these nodes will become active nodes, that is, from the sleep state to the active state, the data will be started Perception and transmission. When the stimulus intensity of the crying event decreases, the discrete event generated ends, and the node will return to the dormant state again, which will save energy consumption of the network. The standard hard threshold is used to describe the value used by the competing sink node when the node is dormant. At the same time, NHT can also be used to determine whether similar information has been repeatedly sent during transmission to the sink node. The standard hard threshold at initialization is expressed as:

$$THN_{initial} = HN - ST \quad (8)$$

The description of the dynamic cluster establishment process is:

The first step is to complete the configuration of the network, and then use the base station to enable the nodes in the network to obtain their location information, exchange

TABLE 2. Online debugging data.

Input (V)	Start	Data Frame															End
		Slave 1			Slave 2			Slave 3			Slave 4			Slave 5			
		X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	
1.6	25	85	84	84	82	82	87	86	78	82	83	85	86	83	78	82	E0
1.9	25	8A	8A	8B	8A	8A	8B	7A	7B	8B	9A	9B	8B	8A	9B	9A	E0
1.3	25	65	66	65	65	65	68	68	69	63	62	67	66	65	64	63	E0

this information to obtain the location information of their neighboring nodes, and the distance between this node and the base station.

The second step is to set the state of all nodes in the network to sleep, and wait for the event-driven wake-up.

In the third step, when a sudden event occurs in this area, the data monitored by the node in the dormant state can be satisfied, then the node will be woken up and transition from the dormant state to the state of sending and receiving data. At the same time, the node becomes a cluster head, and broadcasts cluster information to the nodes in the area. Among them, the size and life cycle length covered by the cluster. After the node becomes a cluster head, the corresponding RETT and AETT values are calculated and updated with new monitoring data MD. And the node calculates the hop count of the clustered information broadcast as K, the formula is:

$$L = \alpha|NT - ST| \tag{9}$$

In the fourth step, after the sleeping node in the network receives the information broadcast by the cluster head, its state changes to an active state. When the ID and AETT value of the received broadcast packet are the same as the previous one, it means that repeated information is received, and the packet is selected to be discarded; when $KI > 0$, the node needs to modify the K value and forward it; When the node in the active state receives different broadcast information CM, it needs to comprehensively judge which cluster to join according to the event severity value, broadcast hop number K and energy residual value.

In the fifth step, when an unexpected event occurs, a corresponding cluster will be formed immediately in the area where the event occurs. The cluster is centered on the first node that is stimulated by the threshold. At the same time, when the nodes that have become cluster heads receive new stimuli again, these nodes will not enter the active state again, and the nodes within the clusters that have already formed clusters will not become cluster heads or member nodes of other clusters. In this way, it is ensured that redundant clustering does not occur in the network.

The sixth step is the release of the cluster. When the active time of the cluster head has ended, ie when $t > AETT$, the cluster is released. And the state of the cluster head and the member nodes in the cluster is changed to the dormant state.

B. CLUSTERING DATA FUSION ANALYSIS OF INTERNET OF MEDICAL THINGS

To deal with the problem of multi-source heterogeneous data fusion in the collection of sports information, the first thing to be solved is the complexity of data information expression, which is determined by the characteristics of multi-temporal and spatial information, multi-source multi-semantic and diversity of data information. Secondly, with the in-depth development of health surveys, the tracking and intervention of individual behaviors requires the mining of more hidden information from external networks. Finally, after the fusion of multi-source heterogeneous data, the data needs to be integrated at different levels to reduce data redundancy and improve decision-making efficiency.

According to the data characteristics of data fusion in motion information collection, in the fusion tree system, the monitoring design scheme based on data fusion is as follows:

(1) In the collection of sports information in the Internet of medical things, the accuracy of the collected data is very high, and the traditional fusion algorithm has relatively little research in this area, so that there is a certain gap between the collected data and the true value, Will affect the correct judgment of the health status of the monitored person. If the health data is on the borderline, and some data is lower or slightly higher than the borderline value, then ignoring these data will cause erroneous records and will not be conducive to the formation of health reports. There is a great advantage in using high-accuracy event-driven cluster-tree data fusion algorithm to obtain fusion value.

(2) Generally speaking, the monitored nodes are randomly distributed within the area to be monitored, so when monitoring is not required during the health monitoring process, the node can be in a dormant state, and then be monitored when the node needs to be monitored. Wake it up. The driver-based cluster-tree fusion algorithm fully takes this into consideration, saving the energy consumption of the network and improving the life cycle of the network. At the same time, if the distribution of nodes in the monitoring area of the network is irregular, or some nodes cannot be effectively monitored, the principle of dynamic clustering can be used to effectively cluster the data according to the cluster-tree structure to ensure the balance of the monitoring area. In the final fusion process, accurate and effective data information is selected.

TABLE 3. Numerical table before data fusion.

Communication radius	5	10	15	20	25	30	35	40
1	4.26	4.99	5.7	5.24	4.75	5.42	5.24	4.75
4	5.48	5.65	5.42	5.23	4.79	5.43	5.45	4.82
16	5.64	5.48	4.78	5.27	5.68	5.68	4.8	5.25
64	5.48	5.36	4.34	5.40	4.63	4.82	4.21	5.44
256	5.48	5.2	5.48	5.72	4.79	4.94	5.82	5.15
1024	5.29	5.36	4.94	5.25	4.82	4.87	5.22	5.25
4096	4.96	5.25	4.03	5.18	4.75	4.8	5.33	5.13
8192	4.86	5.29	5.14	5.19	4.68	4.61	5.23	5.15

TABLE 4. Numerical table after data fusion

Communication radius	5	10	15	20	25	30	35	40
1	4.22	4.66	4.89	5.01	4.62	5.25	5.22	4.62
4	5.3	5.30	5.22	5.02	5.10	5.22	5.41	4.77
16	5.32	5.2	4.41	4.87	5.35	5.22	4.42	5.22
64	5.12	5.13	4.1	5.13	4.13	4.55	4.11	5.21
256	5.13	5.17	5.13	5.21	4.46	4.66	5.42	4.96
1024	5.02	5.17	4.77	5.12	4.72	4.74	5.08	5.1
4096	4.81	5.07	4.10	5.02	4.72	4.74	5.1	5.1
8192	4.68	5.15	5.02	5.05	4.75	4.71	5.02	5.12

TABLE 5. Observation information table.

Communication radius (m)	5	10	15	20	25	30	35	40
Data related range (m)	1	4	16	64	256	1024	4096	8192
Energy consumption ratio	1.2	1.28	1.38	1.5	1.32	1.3	1.32	1.26
Data fusion rate (%)	26	32	37	44	57	66	72	74

(3) In order to make the obtained health faithful, fast and accurate, and to be able to make the right decision in combination with the surrounding environment, multiple information sources are needed in the collection of sports information. The credibility of a single information source is limited, and it is relatively limited. It is very unfavorable for the decision of the entire system information. Therefore, it is necessary to fuse a large number of sensors with multi-source information: collect data from multiple source nodes, According to the threshold to judge the emergency event to activate the node, the node selects the added cluster according to the comparison of different weights to form a cluster type fusion route. The communication distance between the nodes is: $d = \delta \sqrt{\frac{1}{n} \ln n}$, n is the number of nodes, r is the radius of the circular area.

The numerical values of the simulation observation data before fusion are shown in Table 3, the numerical values after fusion are shown in Table 4, and the fusion data observation information is shown in Table 5, in which the unit

transmission and reception energy consumption is set to 100nJ/bit. As the communication radius increases, the data correlation increases, the energy consumption ratio increases first and then decreases, and the data fusion rate increases, proving that the system can effectively fuse data and reduce data transmission in the network.

IV. EXPERIMENTAL VERIFICATION

The simulation network in this article has the following properties:

- 1) Sensor nodes and sink nodes in the network no longer move positions after deployment, and the energy of the nodes is limited.
- 2) The sensor nodes in the network all have the function of data fusion, and all nodes have similar processing and communication capabilities.
- 3) The sensor node can obtain its location information from the base station, and the base station is unique.

TABLE 6. Parameter settings.

Parameter	Value
Monitoring area	150m*150m
Number of nodes	125
Base station location	(70,70)
Node initial energy	3J
Packet length	256byte
Node perception radius	25m
Number of emergencies	40
Incident maximum impact area	25m*25m
E_{else}	50nJ/bit
α	100pJ/bit/m ²

4) The sensor node can save energy by freely adjusting its transmit power and make the channel symmetrical.

The parameter settings of the simulation experiment are shown in Table 6.

The idea adopted in the process of simulating the data analysis algorithm is the loop mode, where each loop process is to select the node with the largest energy among the clusters as the cluster head node (that is, the fusion subtree root), and at the same time A data analysis algorithm is used once in a round to perform fusion according to a cluster-tree structure. According to the remaining energy value of each cluster head node in the network, the fusion path of each cluster head node is calculated. Since the event works within a certain radius, in the area where an emergency occurs, the sensor node that responds is within the coverage of its sensing radius. After the response, the node sends the data packet to the upper-level fusion node, and at the same time transmits the response data according to the specified path. When the remaining energy of the nodes in the cluster in the network is negative, the simulation ends, and at the same time jumps out of this cycle. In addition, except for the energy consumption of the sensors on the fusion path, the other nodes have no energy consumption.

The performance analysis of the motion information collection data analysis algorithm and DD, LEACH, PEGASIS [35] are compared and analyzed, including the network lifetime, network energy consumption, and fusion delay. In this paper, 100, 120, 140, 160, 180, and 200 sensor nodes are randomly distributed within the area of 150mX150m through the simulation program. The sensing radius is 20m and the communication radius is 30m. The remaining parameter settings are the same as shown in Table 6.

Of the four algorithms compared, the DD and PEGASIS algorithms are not cluster-based, so the network lifetime of this part of the simulation experiment is defined as: from the beginning of the network to the first sensor node, failure (ie, the energy is negative) time, the simulation method is the same as the previous section. Figure 4 shows the comparison of network lifetimes of these algorithms. The abscissa represents the number of nodes in the network, and

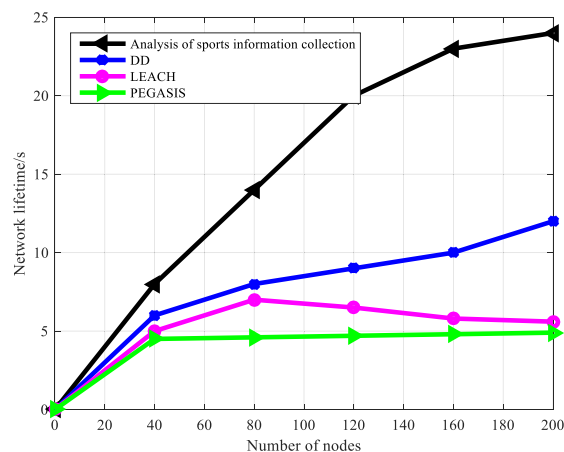


FIGURE 4. Comparison of network lifetime.

the ordinate represents the life cycle of the network. As can be seen from Figure 4, the network lifetime is of the DD algorithm and the motion information collection data analysis algorithm increases with the number of nodes in the network. The network lifetime of the PEGASIS algorithm is generally stable, within a range Not much has changed. But the LEACH algorithm is that as the number of nodes in the network increases, the lifetime of the network decreases. It can be seen from this that the data analysis algorithm has a better network lifetime.

Figure 5 shows a comparison of the average energy consumption of these four algorithms. It can be seen from the figure that the energy consumption of the LEACH algorithm is the highest, followed by the energy consumption of the PEGASIS algorithm, and the energy consumption of the motion information collection data analysis algorithm and the DD algorithm is the smallest. At the same time, under the condition that the number of source nodes and the number of cluster heads are fixed, the data analysis algorithm for motion information collection is significantly more energy-saving than the DD algorithm. This can be explained from two reasons. On the one hand, the data analysis algorithm does not repeatedly query the node path that has been added to the cluster. The DD algorithm queries the entire network before enhancing the path. On the other hand, the data analysis algorithm will follow the In view of the changes in energy consumption in the network, the fusion path to the base station to balance the energy consumption of the network and the DD algorithm do not specify the measures for the direction indication.

The number of clusters in the LEACH algorithm has been fixed. When the number of nodes in the network increases, more nodes transmit data to the cluster head node when an emergency event is detected, so the energy consumed by the algorithm in a node-dense network will increase. In addition, one-hop communication is used in the LEACH protocol, that is, one-hop communication is used to complete the cluster head and the base station. This method is very

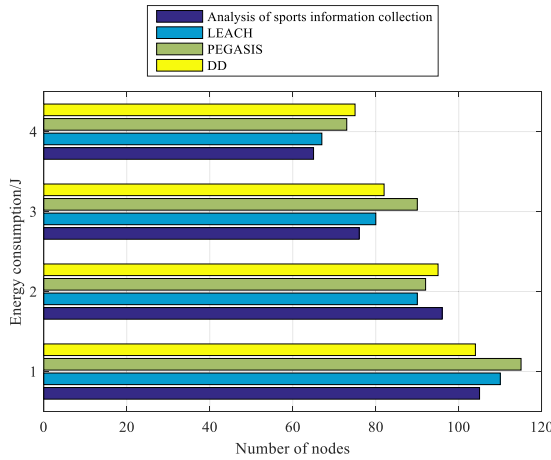


FIGURE 5. Energy consumption comparison.

energy-consuming for the wireless communication energy consumption model, and the LEACH algorithm is affected by the communication radius. The impact on purchase ability is also relatively limited.

While data fusion algorithm reduces network energy consumption, it will also bring a certain degree of delay to the network. This paper conducted delay experiments on these four algorithms, as shown in Figure 6. In the figure, the abscissa indicates the number of nodes, and the ordinate indicates the network fusion delay. As the number of nodes in the network increases, the fusion delay of these several algorithms has increased.

Generally speaking, the factors that affect the size of the delay include data transmission, network congestion, calculation time, convergence waiting, and so on. This algorithm mainly studies data fusion at the network layer, and considers the impact of the overall delay of the network during data fusion. Before performing data fusion on the fusion nodes in the network, it is necessary to wait for the child nodes with more data from the child nodes to use the node as a fusion forwarding node to find the minimum delay fusion path, which will cause a long waiting time., So if there is a calculation formula for fusion latency and minimum fusion path. Compared with other fusion algorithms, the data analysis algorithm can dynamically select the path based on the actual minimum delay without changing the current clustering structure.

As can be seen from Figure 6, the network fusion delay of the LEACH algorithm is the smallest among the four algorithms. This is because all the member nodes in the LEACH algorithm transmit data to the cluster head in a single-hop mode. The data is fused and sent to the sink node, its delay time is mainly in the cluster head. However, for sudden events in the network, the periodic integration of LEACH is not applicable in a strict sense. The delay of the data analysis algorithm is much smaller than that of the DD and PEGASIS algorithms. From an overall perspective, it is an algorithm that

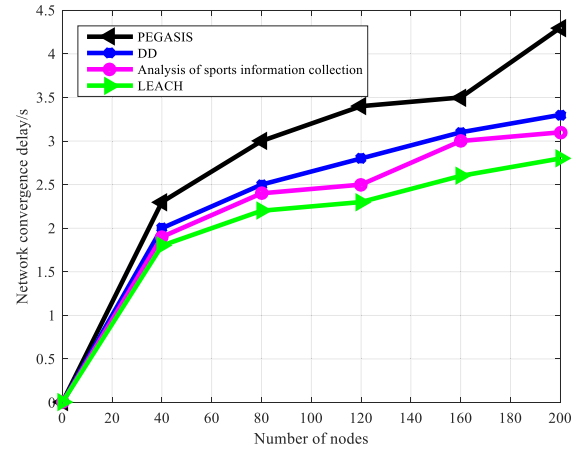


FIGURE 6. Comparison of network delay.

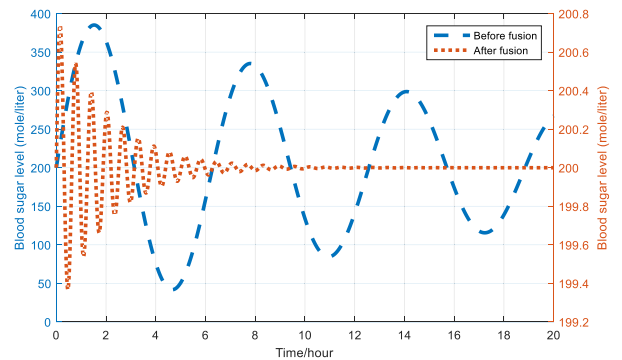


FIGURE 7. Comparison chart before and after data fusion.

can balance energy and delay time, and has good application value.

Adding white noise to the simulation test of motion information acquisition data analysis algorithm, the signal-to-noise ratio is from 0.1 dB to 1 dB, respectively for 60, 85, 105, 156, 205, 410, 500, 600, 820, 1000 nodes collect the monitored blood glucose values, the values obtained before the fusion of the sports information collection data analysis algorithm are shown in Table 7 below, and the blood glucose values after the fusion of the sports information collection data analysis algorithm are shown in Table 8, The figures are based on the true value of 5.0mmol/l.

It can be seen from the above figure that after the fusion of the motion information collection data analysis algorithm is closer to the true value than the data value before the fusion, the ideal data is obtained after the fusion, which can ensure the accuracy of the data to a certain extent. Apply this algorithm to a certain period of time (0-20 hours), set the signal-to-noise ratio to 0.5dB, the obtained data samples are loaded into matlab for simulation experiments, the experimental simulation results are shown in Figure 7.

By operating the recorded values through the special value tracing method, the curve fitting graph in the figure can be obtained. The graph shows that under different time changes,

TABLE 7. Numerical table before data fusion of motion information collection data analysis.

Signal to noise ratio (dB)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
60	5.44	5.05	4.84	5.13	4.76	4.78	5.43	4.78	4.35	5.31
85	5.23	5.32	5.22	5.34	5.22	5.22	5.44	5.34	4.25	5.26
105	5.33	5.46	4.73	4.83	5.43	5.35	5.22	5.35	4.55	5.33
156	5.32	5.35	5.42	5.23	4.52	4.54	5.34	5.40	4.55	5.28
205	5.3	5.43	5.32	5.33	4.7	5.36	5.42	5.27	5.35	5.36
410	5.13	5.16	4.86	5.16	4.67	4.87	5.12	5.41	5.24	5.34
500	4.71	5.13	4.82	5.24	4.75	4.83	5.23	5.28	5.21	5.24
600	4.65	5.12	5.1	5.34	4.49	4.8	5.23	5.34	5.42	5.28
820	4.24	5.12	5.15	5.26	4.68	4.79	5.14	5.28	4.98	5.32
1000	4.85	5.08	5.21	4.94	5.18	4.0	5.31	4.76	5.12	4.87

TABLE 8. Numerical table before data fusion of sports information collection data analysis.

Signal to noise ratio (dB)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
60	5.13	4.68	4.73	5.03	4.92	4.76	5.22	4.84	4.83	5.34
85	5.09	5.02	5.18	5.11	5.02	5.16	5.24	5.03	4.84	5.06
105	5.02	5.13	4.92	4.85	5.22	5.12	5.13	5.06	4.9	5.02
156	5.03	5.12	5.04	5.17	4.86	4.79	5.02	5.07	4.88	5.03
205	5.02	5.09	5.03	5.16	4.87	5.10	5.03	5.12	5.12	5.12
410	5.01	5.02	4.96	5.15	4.96	4.76	5.05	5.03	5.16	5.03
500	4.99	5.04	4.92	5.14	4.92	4.87	5.06	5.05	5.15	5.02
600	4.99	5.03	5.01	5.12	4.86	4.88	5.07	5.06	5.11	5.05
820	4.99	5.04	5.02	5.12	4.93	4.88	5.08	5.07	4.88	5.02
1000	4.95	5.02	5.04	4.89	5.01	4.89	5.04	4.92	5.13	4.93

the fusion data with noise interference can also maintain good accuracy. This algorithm has certain advantages for the medical IoT that requires high accuracy.

V. CONCLUSION

The Internet of medical things is an extremely large and complex system. Research on its architecture is not only basic work but also the key to its future development. After briefly introducing the basic concepts of medical IoT, the medical IoT system architecture and related key technologies were discussed in detail, including middleware, perception information system, network management system, etc. An event-driven cluster-tree data fusion construction algorithm is proposed. This algorithm activates the nodes in the area according to the corresponding threshold under the emergency event, and then the weight of each node determines the joining Clusters. A topology structure combining cluster and tree is used to dynamically cluster and determine the coverage of the corresponding cluster based on the severity of the event, and combined with routing technology to build a corresponding routing tree and prolong the life cycle of the network. At the same time, in order to reduce the fusion delay of data

in the network, a minimum fusion delay path is designed. Finally, through comparative analysis of experimental simulation and traditional algorithms, the experiment verifies the accuracy and timeliness of the algorithm. In addition, in order to obtain the evaluation of system reliability, stability and practicability, a large number of reasonable experiments have been carried out on this system. Through the analysis of the experimental results, the following conclusions are obtained: the relative error of the motion information collection system for the collection of motion acceleration information is within the allowable range. Because its error has a certain degree of positive and negative randomness, the error range is smaller than the repetitive error of people during exercise, Can more realistically reflect human movement.

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