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Research Article

A Human Motion Function Rehabilitation Monitoring System Based on Data Mining

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Human motion interaction technologies have evolved to a new level with the development of traditional reality technology as science and technology have developed. Fully interactive and human motion interaction technologies are becoming more common in fields such as medical rehabilitation and military simulations. Human motion is at the heart of all activity, and motion analysis and human motion are critical theoretical disciplines. Identification is based on behavior and motion in human motion, with attributes such as effectiveness, intelligence, potent interaction, and rich expression data. When studying human movement, many researchers now prefer this method. However, this study was conducted with insufficient suggestions for real-time human motion function assessment, rehabilitation, and improvement. The development of an information monitoring system for human motion function rehabilitation can be used to evaluate the efficacy of patient rehabilitation training. A human motion function rehabilitation monitoring system is created using an effective and thorough design methodology. The system is made up of the rehabilitation monitoring terminal, the human motion function monitoring module, and the medical center monitoring system. Therefore, the motion-based data mining technique is better for the human motion function rehabilitation monitoring system. The normalized proportion of motion features will assist in the creation of a database for human motion mining. The nonlinear classification function is used in this paper to scientifically categorize human motion features to implement data mining techniques for monitoring human motion function rehabilitation. The effectiveness of patient rehabilitation is significantly increased by the use of a human motion-based rehabilitation monitoring system.

1. Introduction

A patient may be required to complete a comprehensive and important physical rehabilitation program to regain their prior strength, flexibility, and fitness after some kind of illness, injury, or surgery. The primary goal is to evaluate and optimize the patients' lifetime capabilities and motion qualities, and it is standard procedure in this environment to continuously monitor the patients' movements. In rehabilitation facilities, traditional physiotherapy-based treatments are frequently used; these treatments indicate the need for qualified professionals and their invaluable competence [1]. The standardized, objective data necessary to fairly assess patients' accomplishments might not be present in these treatments. Since the 1980s, there has been an increase in patients with motor function problems, which has made human motion tracking for rehabilitation a popular research topic. Humans must move their bodies in order to survive, and healthy people move their bodies frequently, while sick people move their bodies much less frequently. Stroke, one of the leading causes of disability in the world, frequently results in a limb or limbs losing all or some of their performance as a result of motor dysfunction [2]. In recent years, neurorehabilitation medicine research has advanced gradually, and the general public has assumed that damaged human motor function could be partially restored. Using scientific rehabilitation techniques could result in complete paralysis, low stamina, loss of motor control, or muscle weakness. On the other hand, looking for an effective rehabilitation treatment method to assist the patient in regaining human motor function will be counterproductive. It not only helps to improve the standard of

living for patients but also reduces the burden on their families and society [3]. The overarching functional design scheme of the human motor function rehabilitation monitoring system clarifies the particular design plan of the subsystem. The monitoring terminal for rehabilitation, the human motor function monitoring module, and the monitoring system for the medical facility are also included in the composition.

Through trials, information on plantar pressure under different motion modes and details on the current gait were acquired. Li et al. are now using fuzzy mathematics theory to characterize human behavior. The significant gait events, such as the contact of the leg and foot, were identified using dynamic baseline monitoring. The screening windows are used to filter the repeated individual monitoring over a specified period for the error monitoring of vital gait events, significantly improving identification accuracy and supplying essential gait data for the categorization of movement patterns. The viability and effectiveness of the fuzzy theory application for human motion identification are established by performing similarities comparisons on each pattern, the relevant levels of motion extraction features, and the relevant levels of motion pattern recognition. Artificial intelligence is expected to provide processing approaches and research projects to meet future demand [4]. Villanueva et al. describe a wearable multisensor system for monitoring human movement in stroke rehabilitation. It is composed of several teeny-tiny modules that can wirelessly connect and transmit motion-related data to an acquisition device. It is beneficial for human motion collecting and monitoring, which is required for activities such as activity detection, measuring physical and athletic performance, and rehabilitation, and according to the results of a series of experiments, we evaluated its performance in real-world environments [5]. Banaee et al. investigated the most cutting-edge methods and algorithms for interpreting data from smart technology used for physiologic monitoring of vital signs in healthcare services in a recent publication. The paper provides an overview of the more popular data mining applications, such as intrusion detection systems, prediction, and decision making, with an emphasis on continuous time-series observations. The study also discusses the suitability of specific data mining and machine learning algorithms used to evaluate the physiological data and provides an overview of the features of the data sets used in experimental verification. Several key challenges for data mining approaches in health monitoring systems have been identified based on this literature review [6].

Rehabilitation training is a method of brain plasticity rehabilitation treatment, and the findings of modern neurorehabilitation medicine and associated studies show that. For human motor dysfunction caused by problems such as stroke, adopting scientific rehabilitation training treatment modalities can effectively recover the damaged human motor function to a corresponding extent. Rehabilitation physicians must conduct a real-time objective evaluation of the effect of rehabilitation training on patients during the rehabilitation training process. Accurately assess motor recovery ability as well as training participation, and effectively adjust the feedback scheme of rehabilitation training based on the evaluation results. The efficiency of rehabilitation training is improved, and the effect of rehabilitation is maximized. The process of analyzing and extracting information from large datasets is called data mining. It is important to use a data mining method to monitor the rehabilitation training process for patients with human motor dysfunction and deep understanding. The effect of rehabilitation training under objective data is significant in terms of improving the effectiveness of rehabilitation treatment for patients. The overall functional design scheme of the human motor function rehabilitation monitoring system clarifies the subsystem's specific design scheme. The rehabilitation monitoring terminal, the human motor function monitoring module, and the medical center monitoring system are all part of this system.

The innovation of this paper is as follows:

(i) Firstly, the data mining method based on motor features was applied to the human motor function rehabilitation monitoring system, and human motor function rehabilitation monitoring data mining was realized

(ii) Secondly, in comparison with the traditional monitoring system of human motor function rehabilitation, the data mining-based monitoring system of human motor function rehabilitation is presented

(iii) Finally, overall performance improved both the real-time performance of the human motor function rehabilitation monitoring system and the effect of patient rehabilitation training

The remainder of the paper is structured logically as follows: Section 2 shows related work; Section 3 represents the human motion function rehabilitation monitoring system based on data mining; Section 4 demonstrates the human motion function rehabilitation monitoring method based on motion characteristics, and Section 5 shows the experimental results and analysis. Finally, Section 6 concluded this work.

2. Related Work

In the early years, relevant researchers at home and abroad began to conduct in-depth research on human physiological parameters and rehabilitation monitoring, and they achieved some research results through their efforts. Li et al. proposed a monitoring system for human remote rehabilitation training, which provides a remote rehabilitation training monitoring platform for patients in rehabilitation. The terminal-controlled module processor is a 32-bit STMicroelectronics (STM32) integrated circuit that controls data acquisition, processing, and transmission. Complete the communication between the acquisition device and the cloud server during the rehabilitation process using the Message Queuing Telemetry Transport (MQTT) protocol. Analyze the time-frequency domain of electromyography (EMG) signal to calculate the specific situation of muscle

strength and muscle fatigue and calculate the activity of human joints from the signal of attitude sensor for rehabilitation evaluation of rehabilitation training. To complete the interaction between the browser and the cloud server, use the Tomcat server to display the patient's rehabilitation data on the web page. However, remote rehabilitation training monitoring, uploading, and the mointoring system need help to discharge stroke patients for rehabilitation treatment and early recurrence warnings. A multifunctional human motor function rehabilitation monitoring system was created, which included human physiological signals, treatment, and data analysis. The therapeutic device uses transcranial direct current stimulation technology to accurately output constant and direct current. The patient's heart rate and other pertinent data are then routinely monitored by the intelligent bracelet, which is created as an adjunct rehabilitation monitoring device. Send the rehabilitation data to the mobile phone via Bluetooth, and then use the mobile phone to summarize the treatment records and vital signs data before uploading the summarized data to the cloud for in-depth analysis. It is specifically used to adjust the rehabilitation treatment plan or for early warning of stroke recurrence. The development results show that the monitoring system can not only meet the needs of human motor function rehabilitation treatment but also realize the interconnection between cloud and equipment. The system can provide effective solutions for personalized treatment of stroke, recurrence early warning, and database, but the system has the problem of high cost [7]. Yang et al. describe a human rehabilitation monitoring system based on an embedded controller designed to meet the needs of human postoperative recovery training. A multifunction human rehabilitation training mode, movement posture, EMG signal acquisition, and safety protection are realized. The training process is identified and analyzed by using the random forest machine learning method and linear regression method. The results show that the designed human rehabilitation control and monitoring system can use Android for portable control. To complete the intelligent analysis of the rehabilitation training process, use the monitoring signals in the training process. The random forest method has advantages over the linear regression method in human motion recognition, but the rehabilitation effect of this method is poor [8]. Guan et al. propose a human rehabilitation movement monitoring method based on human posture information to control rehabilitation training for patients with human motor dysfunction after surgery. It is a data collection system for human motion data that is customized to the structural characteristics and functional requirements of rehabilitated patients. The kinematic model of human rehabilitation is built, and a behavior information collection system for human posture is established on the rehabilitation platform. The software evaluates the expected follow-up speed of rehabilitation based on the behavior change information representing human posture obtained from the displacement analysis sensor. To reduce the error generated, the tracking controller is designed using the fuzzy control method and a simulation experiment. However, this method has the problem of poor real-time performance in the process of patients' real-time tracking movement and realization of the following effect of rehabilitation on patients' motion posture [9].

3. Human Motion Function Rehabilitation Monitoring System Based on Data Mining

Figure 1 depicts the overall framework of the human motor function rehabilitation monitoring system. The data mining-based human motion function rehabilitation monitoring system is primarily composed of a large number of collection nodes for physiological parameters worn by patients. A self-organized wireless network is established between the nodes, and the physiological parameter signals are transmitted to the convergence node of the wireless network through the Zonal Intercommunication Global (ZigBee) protocol. ZigBee is a low-power, low-data-rate M2M (machine-to-machine) wireless network and Internet-of-Things (IoT). The ZigBee protocol is based on IEEE 802.15.4. A ZigBee network is made up of several full-function devices (FFD) that gather data from nearby reduced-function devices (RFD).

The local monitoring system consists of embedded portable devices connected to a wireless network, with a sink node collecting physiological data. The main purpose of the medical center's monitoring system is to create a database of multiple physiological parameters of patients and extract them. Identify patients' physiological and psychological states and evaluate patients' rehabilitation effects in real time [10, 11].

3.1. Design of Rehabilitation Monitoring Terminal System. Figure 2 shows the composition of the rehabilitation monitoring terminal system. The physiological parameter acquisition module and the data transmission module are included in the design of the rehabilitation monitoring terminal system. The physiological parameter acquisition module is a multiparameter physiological module that measures and monitors heart rate, noninvasive blood pressure, respiration, oxygen saturation, temperature, and Enteric Coated (EC). The acquisition module of physiological parameters must install the node in the appropriate position of the patient's body to collect the patient's human physiological signals. The selection of physiological signals is mainly divided into collecting electromyography (EMG), electrocardiography (ECG), pulse, and triaxial acceleration. In the node design of hardware, medical sensors and methods for specific physiological signals and signal conditioning circuits such as filtering are composed [12, 13].

The rehabilitation data transmission module in the hardware platform makes use of data communication between network nodes and the iris node. The integrated processing chip of the node is the controller and the radio-frequency (RF) chip is the wireless transceiver. The tiny operating system and network cable network routing protocol design are used in the software implementation. The designed networking application is added to the control chip of each node, which can realize the rehabilitation data transmission between wireless nodes, as well as some characteristics such as low-power consumption, load balancing, and robustness.

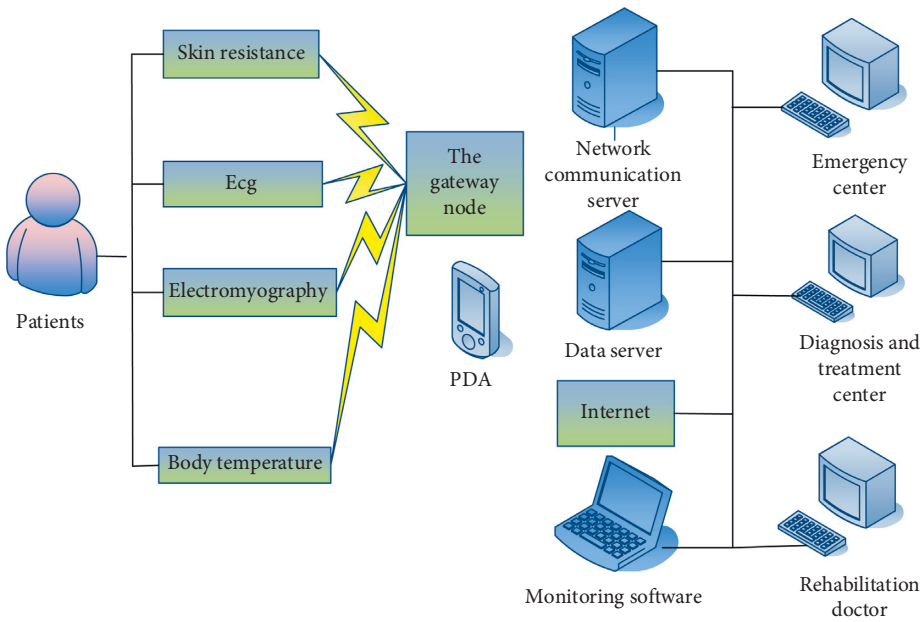

Figure 1: Overall frame diagram of the rehabilitation monitoring system.

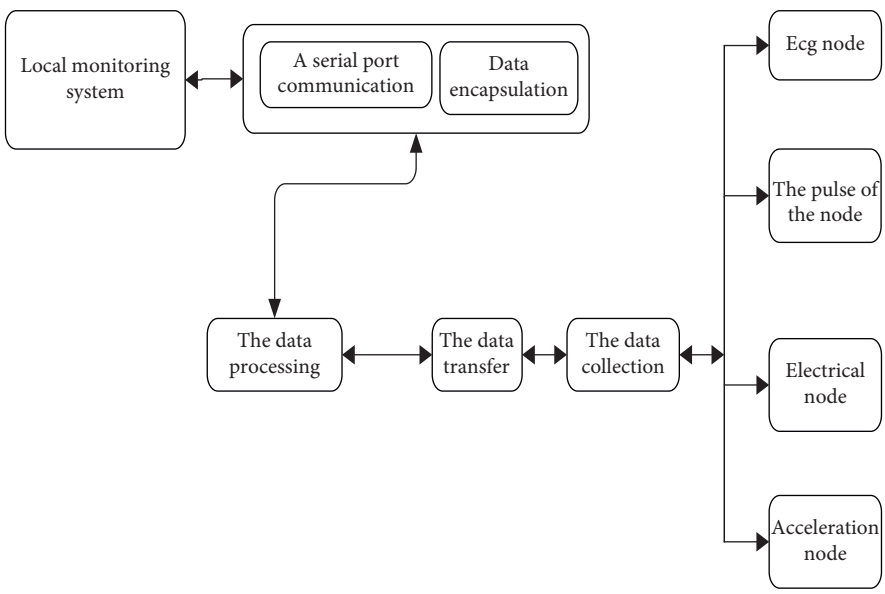

Figure 2: Rehabilitation monitoring terminal system composition diagram.

3.2. Human Motor Function Rehabilitation Monitoring Module. Figure 3 shows the composition of human motor function rehabilitation monitoring. The unit hardware of the monitoring module is an embedded operating system using the processor core board of the Advanced RISC Machine (ARM9). The software realizes the terminal node data collection, processing, and storage of rehabilitation data and provides the user interface for images for patients. It uploads the collected rehabilitation training data to the medical monitoring center. The local monitoring system module specifically includes embedded transplantation and multiple modules such as data acquisition, data storage, display unit, and network communication [14, 15].

The rehabilitation training data acquisition module serves as the interface between the network node and the ARM processor, and it must analyze various physiological data types. The node collects data using the serial communication protocol, and data processing is the core module in the local monitoring system. It must process and store various physiological signals collected from patients, as well as various control instructions received from the display unit, which is a designed monitoring interface. In the development environment, a graphical interface primarily displays the collected human physiological signals of patients in the form of a real-time dynamic curve. The network communication module is a bridge connecting the local monitoring system and the

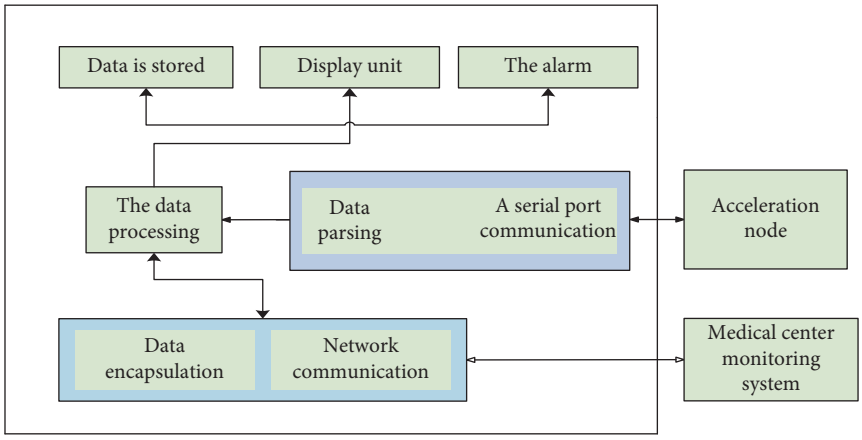

Figure 3: Local monitoring system composition diagram.

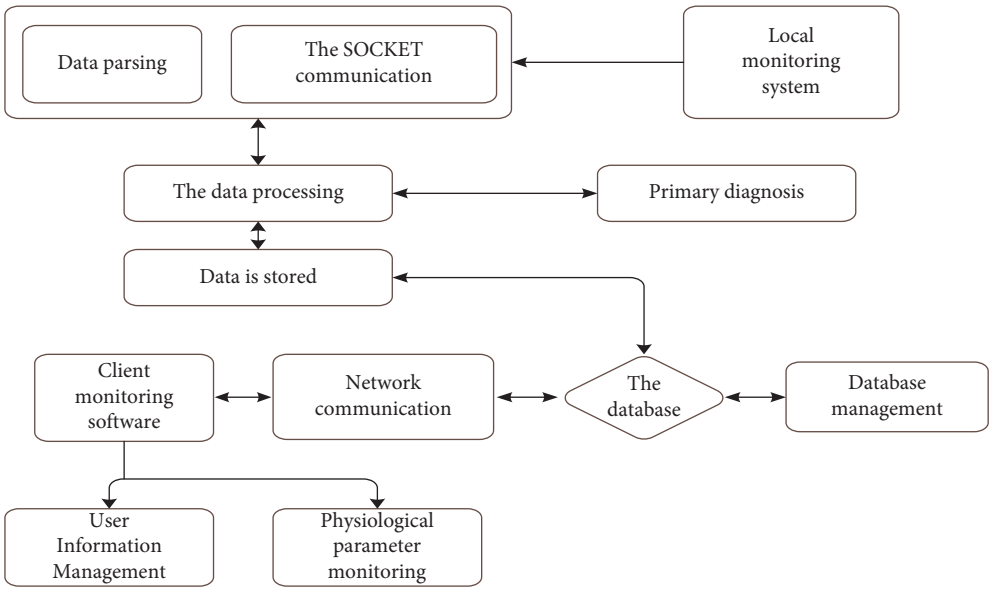

Figure 4: Composition of the medical center monitoring system.

monitoring system of the medical center. The module adopts Transmission Control Protocol (TCP) and realizes the sending and receiving of rehabilitation data through the socket communication model design.

3.3. Medical Center Monitoring System. Figure 4 shows the composition of the monitoring system of the medical center. The medical center's monitoring system is built on the Client/Server framework, which consists of monitoring software for both the server and the client. The server realizes the communication with the local monitoring system and client monitoring software, as well as the storage and processing of rehabilitation data. It specifically includes multiple modules such as network communication, user information management, and ecological parameter monitoring [16, 17].

The communication server is built based on the TCP, connected with a socket, receives the link from the online local monitoring system and the analysis data packet of the communication protocol, and stores it in the database. The data processing module includes data analysis, preliminary diagnosis, data storage, and so on. The physiological parameters are mined by a data mining algorithm, and the physiological features are extracted and preliminarily diagnosed. The processed data is stored in the database for query and call by the monitoring software of the client. User information management mainly saves the patient's personal information and physiological data. The monitoring module of physiological parameters uses the call database to obtain the physiological data of patients and displays electrocardiogram (ECG), muscle point, pulse, and other signals in the form of a waveform curve. It is also capable of monitoring physiological parameters. It will provide an early warning if a patient's physiological parameters exceed the set threshold [18, 19].

3.4. Data Frame. The data frame defines the format of the data packet when transmitting rehabilitation data, including the destination node, source node, and the length of the data packet. The specific format of the data frame is shown in Table 1.

4. Human Motion Function Rehabilitation Monitoring Method Based on Motion Characteristics

There is a close relationship between human motion characteristics and human actions. It is necessary to analyze the importance of human motion characteristics from the direction of human motion. We will talk about the characteristic threshold of patients' human motion.

4.1. Motion Feature Extraction. Some of the patient's human motion features are deleted based on the threshold to obtain the real motion behavior-related features. In general, the motion feature weight coefficient of the patient must be calculated using parameters such as intensity and amplitude. The patient's human behavior movements are described to convey the significance of the patient's human motion feature. Suppose M_j is the intensity parameter of the patient's human motion characteristics, M_0 is the motion amplitude parameter of human motion characteristics, and Q is the number of human motion characteristics. Calculate the threshold change parameter:

$$S_{M\ DS} = \frac{M_1 + M_2}{QT}. \tag{1}$$

In the process of patients' rehabilitation training, the importance of motor function intensity parameters is higher than that of motion amplitude parameters. Therefore, they must be given different weight coefficients [20, 21]. By setting the weight coefficient proportion in the golden section mode, formula (1) can be transformed to obtain

$$S_{M\ DS} = \frac{2\left(0.618M_j + 0.382M_0\right)}{M_j + M_0}. \tag{2}$$

In formula (2), $S_{M\ DS}$ represents the parameter of threshold change, which can map the patient rehabilitation data to the range of (0, 1). The mapping formula is represented by

$$x = 1 - \exp\left(S_{MDS}\right). \tag{3}$$

In formula (3), χ represents the influence of the threshold change parameters on the threshold. Assuming that the duration of the patient's human motion is U_e and the total duration of human motion is U_s, the characteristics of the motion time are smoothed to eliminate the error, and the threshold can be expressed by

$$\varepsilon = \left(\beta U_e + U_s\right)(1 + \chi). \tag{4}$$

If the characteristic parameter of human motion in the process of rehabilitation is greater than the threshold, it can be judged that the feature is the real motion feature of the human body.

4.2. Optimizing the Data Mining Process of Human Motor Function Rehabilitation. Through the nonlinear classification function, the data mining of human motion function rehabilitation monitoring can be realized based on extracting the human motion characteristics of patients. Let the set composed of human motion characteristics of patients be described by $\left\{y_j, z_j\right\}$, $z_j \in (1, -1)$, and the classification function be expressed by

$$g(y) = x \bullet y + c. \tag{5}$$

If the classification interval of patient rehabilitation monitoring data is the maximum, the requirements of the following formula must be met:

$$z_j\left[(x \bullet y) + c - 1\right] \geq 0, \quad j = 1, 2, \ldots, p. \tag{6}$$

The solution of the optimal classification function can be expressed by

$$\gamma(x) = \frac{1}{2}x = \frac{1}{2}(x \bullet x). \tag{7}$$

The Lagrange factor is introduced into the classification function of patients' human motor function rehabilitation monitoring, and the function represented by the following formula can be obtained:

$$M(x, c, b) = \frac{1}{2}(x \bullet x) - \sum^{j=1}_{p} b_j\left\{z_j\left[\left[(x \bullet y) + c\right] - 1\right]\right\}. \tag{8}$$

It is concluded that the classification function of human motion characteristics in the process of patient rehabilitation monitoring can be expressed as

$$g(y) = \operatorname{sgn}\left\{\sum^{j=1}_{p} b_j^* z_j\left(y_j \bullet y\right) + c^*\right\}. \tag{9}$$

According to the above classification function of patients' human motion features, patients' human motion features can be divided into different categories of motion feature sets [22, 23]. According to these characteristics, the motor function data mining process in the process of patient rehabilitation monitoring can be described by

$$g(y) = \operatorname{sgn}\left\{\sum^{j=1}_{p} b_j^* \exp\left(\frac{\left|y - y_j\right|^2}{\varepsilon^2}\right) + c^*\right\}. \tag{10}$$

In the process of human motion mining of patients' human motion function rehabilitation monitoring data, the most important problem is how to select scientific parameters.

Table 1: Data frame format of the terminal node.

The field names	Length (bytes)
Tiny OS Header	6
Xmesh Header	8
Xsensor Header	5
Data Payload	17
CRC	2

If the parameters are not scientific, it will have a great impact on the accuracy of human motion mining results [24, 25]. Therefore, we must optimize the penalty coefficient and the width of the kernel function through the radial basis kernel function. According to the optimized results, the optimal rehabilitation effect of human motor function is obtained, and the research on human motor function rehabilitation monitoring system based on data mining is completed.

5. Experimental Result and Analysis

Experiment verification is used to demonstrate the performance of the human motion function rehabilitation monitoring system based on data mining. Table 2 shows the experimental environment of the rehabilitation monitoring system.

Figure 5 shows the mining error comparison between the human motion function rehabilitation monitoring method based on motion feature data mining proposed in this paper and the human motion function rehabilitation monitoring method based on traditional data mining.

Figure 5 shows that at the start of the experiment, the mining error of the traditional data mining human motion function rehabilitation monitoring method was 29%. However, as the amount of data increases, the mining error gradually increases, reaching 42% before beginning to decline. Traditional data mining has a high overall error rate, resulting in poor data mining accuracy. At the start of the experiment, the mining error of the human motion function rehabilitation monitoring method based on motion features proposed in this paper was low. Although data increases slightly, the overall increase does not exceed 10%. This shows that the mining accuracy of the method proposed in this paper is high enough to effectively mine important patient information. They assist doctors in understanding the rehabilitation situations of patients so they can adjust the rehabilitation scheme for patients and improve the rehabilitation effect of patients during the rehabilitation monitoring process. The mining times of the motion feature data mining-based human motion function rehabilitation monitoring method and the traditional data mining-based human motion function rehabilitation monitoring method are compared in Table 3.

It can be seen from Table 3 that the time of traditional data mining methods in mining human motor function rehabilitation data is 47 s while the time required to mine human motor function rehabilitation data using the action feature data mining method proposed in this paper is 15 s. This shows how using the method outlined in this paper can effectively increase the effectiveness of data mining and assist medical professionals in quickly analyzing patient rehabilitation monitoring data. The human motion function rehabilitation monitoring system of the method suggested in this paper and the human motion function rehabilitation monitoring system are compared in real time in Figure 6.

The analysis of Figure 6 shows that the real-time performance of the human motor function rehabilitation monitoring system of the method proposed in the document is not high as a whole [3]. The real-time performance gradually increases with the increase of data at the beginning of the experiment. The real-time performance of the proposed human motion function rehabilitation monitoring system in the document gradually improves, but then declines when the experimental data reaches 1000 [4]. Throughout the experiment, the real-time performance of the human motion function rehabilitation monitoring system proposed in this paper was excellent. This is because this system uses data mining to monitor the rehabilitation training process for patients with human motion dysfunction. To understand the effect of rehabilitation training on patients in real time, we must first master the effect of rehabilitation training under objective data. The human motion function rehabilitation monitoring system of the method suggested in this paper and the human motion function rehabilitation monitoring system are compared in terms of overall performance in Figure 7.

Figure 7 shows that the overall performance of the human motor function rehabilitation monitoring system was better at the start of the experiment, but began to deteriorate as the data volume increased. At the start of the experiment, the overall performance of the human motor function rehabilitation monitoring system was slightly lower. This paper presented the overall performance that improved gradually as experimental data increased, but system performance was slightly significantly underrepresented in comparison with the rehabilitation monitoring system. The more stable overall performance of the data mining-based monitoring system for human motor function rehabilitation presented in this paper

Table 2: Experimental environment of the rehabilitation monitoring system.

Type	Experimental environment
The operating system	Windows 7 (64 bits)
Development platform	Unity3D, Visual Studio (2017)
Development of language	C++
Memory	4 GB (gigabyte)

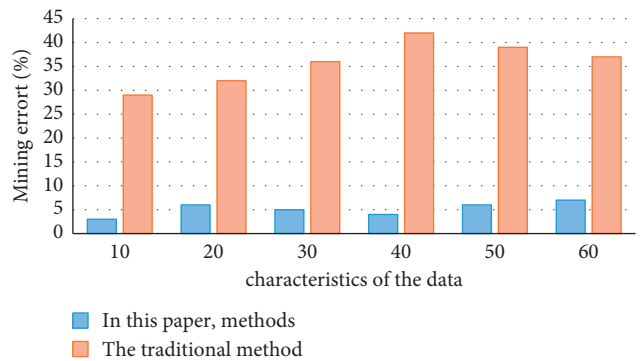

Figure 5: Comparison of mining errors of different mining methods.

Table 3: Comparison of mining time of different mining methods.

Different methods	Mining time (s)
Proposed methods	15
Traditional method	47

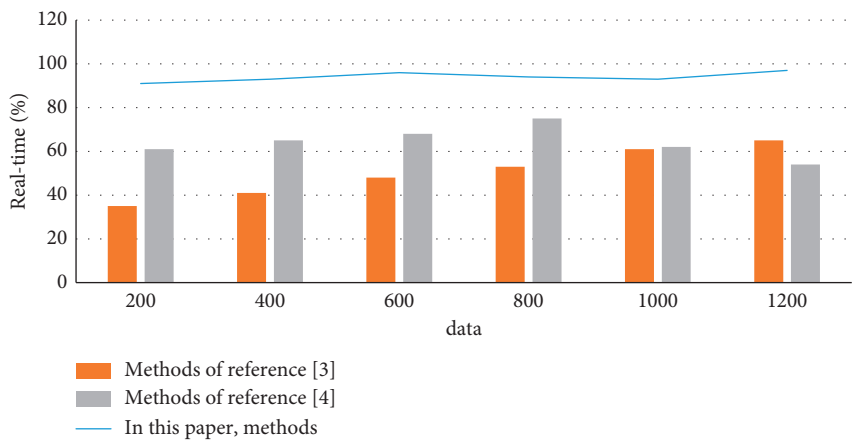

Figure 6: Comparison of the real-time performance of rehabilitation monitoring systems under different methods.

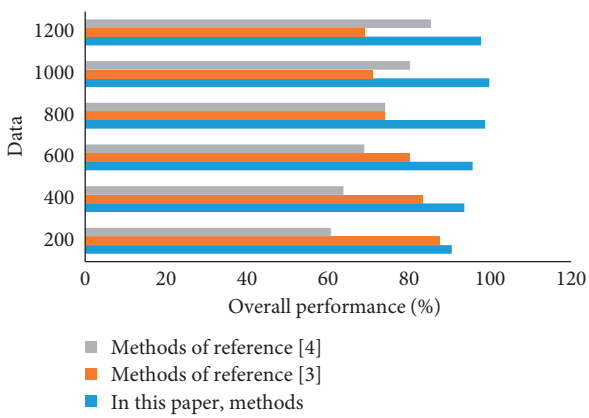

Figure 7: Overall performance comparison of rehabilitation monitoring systems under different methods.

is because the data mining method presented in this paper classifies human motor features through a nonlinear classification function, which enables the mining of human motor function rehabilitation monitoring.

6. Conclusions

Human motion recognition research is expected to show that motion recognition is improved by human motion recognition. Human motion recognition science is progressing, and new technologies to improve our daily lives are emerging. This paper presented the design of a data-mining monitoring system for the restoration of human motor function. As the number of people suffering from human motor dysfunction as a result of illnesses such as stroke rises, this can be used in rehabilitation therapy. Relevant studies have shown that the use of scientific rehabilitation training can restore the damaged human motor function of patients to a great extent. In the process of rehabilitation training, rehabilitation doctors should monitor the physiological information of patients in real time. This paper uses data mining techniques to design and implement a human motion function rehabilitation monitoring system to meet this demand. This system enables timely evaluation of the training effect of patients' rehabilitation as well as timely modification of the rehabilitation plan. The system processes and analyzes the physiological information of patients to improve the effectiveness of rehabilitation training. The results of the experiments show that the human motion function rehabilitation monitoring system suggested in this research has good overall performance. This significantly improves the system's real-time performance and patient rehabilitation effectiveness. Although the system works well, it will be improved to increase battery life, reduce sensor size and weight, and improve the temporal synchronization of various sensor signals. The proposed system will be a component of a networked rehabilitation system that will also include sensors and rehabilitation robotics [26].

Data Availability

All the data are available in this paper as part of the publication.

Conflicts of Interest

The author has no conflicts of interest in the publication of this paper.

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