Hindawi
Mathematical Problems in Engineering
Volume 2022, Article ID 7587780, 9 pages
https://doi.org/10.1155/2022/7587780

Research Article

Design of Agent-Based Embedded Family Remote Medical Monitoring System

Haixia Zhang

Henan Industry and Trade Vocational College, Zhengzhou, Henan 450000, China

Correspondence should be addressed to Haixia Zhang; zhanghaixia@hngm.edu.cn

Received 20 January 2022; Revised 14 February 2022; Accepted 2 March 2022; Published 5 April 2022

Academic Editor: Gengxin Sun

Under the strategic background of the Internet and big data, the technical means of telemedicine show strong advantages in the consultation and treatment of various acute and chronic diseases so that the majority of patients can enjoy high-quality medical resources and save unnecessary costs. The resulting medical management decision-making has also become a research topic widely concerned by experts and scholars in relevant fields at home and abroad. In this article, the multiagent optimization decision-making problem in telemedicine has not formed a systematic research system, and there is a lack of corresponding decision-making analysis methods. In view of this, based on the optimal decision theory and decision-making method in telemedicine, this article focuses on the preferences and behavior strategies of participants in the context of telemedicine and makes a phased and in-depth foundation for management and the decision-making of each link of telemedicine. Theoretical research and specific decision analysis methods have certain theoretical and practical significance. The design ideas and implementation process of the acquisition converter and client software are introduced in detail. In order to support the system with good scalability and maintainability, not only is a communication plug-in designed above the transmission layer, but also a transcoding plug-in is designed to support the protocol conversion of medical equipment. The design idea and implementation process of acquisition converter and client software are introduced in detail.

1. Introduction

With the rapid development of communications and medical and biosensor technologies, healthcare services have been valued by the general population, patients with diseases, and medical staff around the world [1]. Nowadays, medical care is no longer limited to the treatment of diseases but also includes the prevention of chronic diseases or other health services. In the general population, people not only pay attention to information about diet and health in daily life but also pay attention to their own physiological parameter information. Wearable devices such as pedometers and heart rate monitors are becoming more and more popular. The elderly or people with chronic diseases are more likely to have diseases such as hypertension, diabetes, coronary heart disease, and cerebral hemorrhage [2]. They pay more attention to their own physiological information such as blood pressure, blood sugar, blood oxygen, and fat content [3–5]. The remote medical monitoring system includes a variety of medical equipment, such as blood pressure monitors, blood oximeters, electrocardiograms, weight scales, and blood glucose meters. These devices usually have their own sensing devices to collect user physiological data and then display the results in the terminal device [6]. Of course, with the rapid development and popularity of the Internet, with the help of mobile Internet and biomedical sensing technology, the physiological data measured each time can be transmitted to the remote service center for data integration and provided to professionals for research [7].

The current medical equipment has a single function, various manufacturers use different communication protocols, and the data transmission format is also inconsistent. This causes the physiological data obtained by the user to be displayed each time it is difficult to store permanently, and the integration of physiological data cannot be unified [8]. In the end, it is difficult for medical and health data to be collected and used effectively. In addition, different companies launch different products of medical and health data management systems, and the communication interfaces and protocol formats used are often different, which makes their respective systems have a strong closedness [9–12]. For example, a medical device produced by company A can only use its designated medical and health data management system. The physiological data measured by the medical device produced by company B cannot be collected by company A. In the end, it can only repeat the development of similar medical health data by itself [13]. Management system: this brings inconvenience to ordinary users and it is difficult to integrate the physiological data collected by these devices for sharing or research. In order to realize the sharing of medical information, an open standard protocol is needed to solve the problem of interoperability between devices. The development of a medical data collection and transmission system based on the standard protocol not only solves the problems encountered in data collection but also reduces the user's use cost, facilitates users to view physiological health data at any time, and also facilitates doctors and researchers to collect data [14]. Physiological data for diagnosis and research: this article proposes research directions based on actual problems encountered in scientific research projects, with the purpose of solving current medical equipment data automatic collection and compatibility-related issues [15]. It adopts the IEEE 11073 series standards formulated by the Continua Alliance and realizes a "family-level" collection and transmission system [16].

The system is mainly composed of two parts: acquisition converter and client software. Object models are established for four types of medical equipment, including blood pressure monitors, blood glucose meters, blood oximeters, and weight scales. In the session layer, according to the requirements of the communication model in the protocol, the communication format of the session message is designed, the session process is managed, and the transmission of device configuration information and measurement data is realized. Acquisition converters and client software according to the home environment are designed and implemented, and communication plug-ins are used to solve various communication transmission needs. For the access of multiple devices, a transcoding plug-in is designed to connect to medical devices, and the original custom data format is converted into the IEEE 11073 format to solve the problem of incompatibility between client data collection and nonstandard equipment. In the client software, functions such as protocol analysis, data visualization, and management are realized.

The former implements the standard protocol and converts the data format customized by the original manufacturer to meet the standard requirements, and the latter is responsible for the unified collection of standard medical equipment or the data transferred after the former conversion. Analyze the standard protocol; design and implement the domain information model and service model in the presentation layer according to the standard requirements.

2. Design Requirements for Home Telemedicine Monitoring

2.1. System Requirements and Design Goals. As personal health testing equipment becomes more and more compact and portable, ordinary households now purchase many relatively low-cost health measurement equipment, such as blood pressure monitors and blood glucose meters [17–19]. These medical devices are usually relatively simple to use, but the interfaces are not uniform and the communication transmission protocols adopted are also inconsistent. It is difficult to use the same system to collect the data sent by these devices. The specific reasons are as follows.

2.1.1. Physical Connection. In terms of the physical connection between medical equipment and other smart devices, usually some devices have a specific form of a physical interface. These interfaces can be divided into wireless and wired in terms of manifestation. The physical connections are different due to the different manufacturers, types, uses, and attributes of the equipment. For example, the common wired connections are serial interfaces, parallel interfaces, USB interfaces, and networks. Interfaces and wireless connections are mainly divided into WiFi, Bluetooth, and ZigBee . In order to meet the needs of different hardware interface connections, the system should be designed with or compatible with multiple types of hardware interfaces and use different connection methods to collect data generated by medical equipment.

2.1.2. Data Communication. In order to ensure the reliable transmission of medical equipment data, equipment manufacturers usually formulate a series of data communication protocols, including data format, sending sequence, confirmation, retransmission, and error detection requirements. At present, medical equipment often uses different transmission protocols due to their different uses and attributes. Even the same type of equipment may customize different private protocols according to their own needs due to different manufacturers. For example, the device transmission method may be active or passive, the data may be transmitted in single or multiple times, and the transmission content and verification algorithms may also be different. Therefore, the system needs to parse the private protocol and be able to obtain the data generated by the medical device.

2.1.3. Protocol Conversion. After obtaining correct and complete data or messages, different medical devices adopt different data structures and coding rules for the output data. Data structure refers to the organization of information items in the data, and the encoding method is usually character encoding or binary expression. Better data structure and coding rules can bring efficient transmission and storage efficiency. In order to realize the sharing of information between devices, consistent semantic analysis and understanding are required, and a standard information reference model and the establishment of terminology specifications are required, as shown in Figure 1. The IEEE 11073 standard protocol is an open reference protocol with sufficient scalability. It retains the original data of medical equipment that cannot be converted and converts the expression of private data into standardization to facilitate the interconnection and intercommunication of medical equipment.

Through specific analysis of the physical connection between medical equipment, data communication, and protocol conversion, the designed system should adopt flexible wireless connection technology, implement a variety of commonly used transmission protocols, and provide extended support for other protocols [20]. In addition, the system should also have a standard reference, and information representation and term names should be standardized. The goal of this article is to design and implement a collection and transmission system, which aims to solve the incompatibility status of the various medical equipment on the market with their respective collection management systems so that users can use it better and more conveniently and contribute to medical health. For further exploration of the automatic collection of data, according to the application scenario of the system, it should have the following basic functions:

(1) It supports the direct access of medical equipment conforming to the IEEE 11073 standard and can identify standard configuration information and accurately analyze the measurement data transmitted by the medical equipment.

(2) supports the protocol conversion of common medical equipment currently on the market and can use the same system to collect data generated by nonstandard medical equipment.

(3) compatible with medical equipment interface types; the access interface of the system should have universal applicability and scalability.

(4) stores and transmits measurement data.

(5) supports the expansion of wired and wireless network transmission methods and realizes the two commonly used wireless transmission requirements of WiFi and Bluetooth. Among them, wireless connection technology has very good flexibility and, to a large extent, can avoid the awkwardness of serial cable connection.

2.2. Construction of Agent Embedded System. The topological structure of the whole system is mainly composed of four parts.

2.2.1. Medical Equipment. As the data source of this system, the main function is to collect personal health and physiological data, including common personal health equipment, such as blood pressure monitors, weight scales, oximeters, and blood glucose meters. These personal health devices are usually relatively simple to use, but different devices on the market use different protocols for communication and transmission depending on their attributes and uses. This article uses the acquisition converter to connect these nonstandard medical devices and convert them to standard requirements and then connect to the client, while the manufacturer's medical devices that meet the standard requirements can be directly connected to the client.

2.2.2. Acquisition Converter. As the acquisition front end of ordinary nonstandard medical equipment, it mainly collects blood pressure, blood sugar, blood pressure, weight, and other medical sensor data and classifies and converts various heterogeneous medical sensor data to form IEEE 11073 The "Agent" defined by the standard. These agents fully express a standard medical device. They generally run on relatively inexpensive, relatively simple-functioning, small-sized, battery-driven devices and usually lack display functions or user operation interfaces. As the core part of the system, it is responsible for outputting the proprietary protocol adopted by the original manufacturer as the IEEE 11073 standard protocol requirement and transmitting data and configuration information to the client in two wireless communication methods (WiFi and Bluetooth).

2.2.3. Client. As another concept defined by the IEEE 11073 standard, "Manager" is responsible for the unified transmission and storage of data sent by medical equipment. The management is generally run on PCs, smartphones, tablets, and set-top boxes. For devices with strong computing power, ordinary PC uses TCP/IP protocol to receive the data sent by the acquisition converter. When running in the Android environment of a smartphone, this part selects Bluetooth communication to connect to standard medical equipment or acquisition converters. It needs to realize the analysis of the IEEE 11073–20601 standard protocol. In addition to identifying the configuration information of the device, it also needs to classify and manage the measurement data and provide a convenient visual display effect. For medical devices that implement standard protocols, the client does not need to make any modifications and can automatically identify and collect the measurement data sent by the device.

2.2.4. Remote Support Server. As a server application, this part can permanently store and analyze the collected health and physiological data. The data classification can be shown in Table 1. In addition to mainly providing data management and user personal information management functions, it can also provide other services such as disease management, dieting services, and fitness services.

After completing the topological structure design of the system, the entire collection and transmission system needs to be designed in software layers [21]. Although the Continua Health Alliance gave a reference system structure and communication interface, it did not give a specific implementation method. This article is aimed at home application scenarios to ensure that the system supports multidevice access and cross-platform communication capabilities and

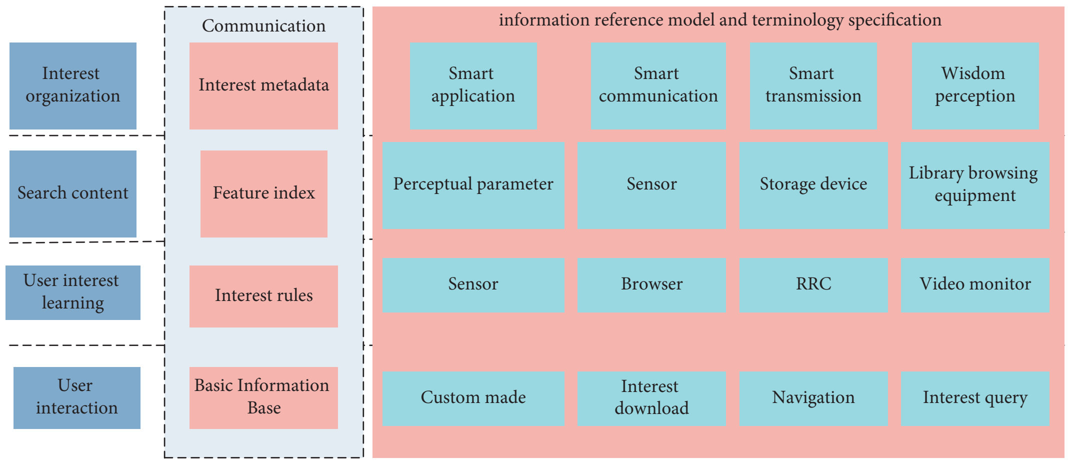

Figure 1: Establishment of the information reference model and terminology specification.

Table 1: Server information.

Health information				Functional service		
Heart blood pressure information	Blood glucose information	Appearance information	Sleep information	Disease management	Diet service	Fitness service
Index 1	Index 1	Index 1	Index 1	Function 1	Function 1	Function 1
Indicator 2	Indicator 2	Indicator 2	Indicator 2	Function 2	Function 2	Function 2
Indicator 3	Indicator 3	Indicator 3	Indicator 3	Function 3	Function 3	Function 3
Indicator 4	Indicator 4	Indicator 4	Indicator 4	Function 4	Function 4	Function 4
Indicator 5	Indicator 5	Indicator 5	Indicator 5	Function 5	Function 5	Function 5
Indicator 6	Indicator 6	Indicator 6	Indicator 6	Function 6	Function 6	Function 6

also refers to the system architecture recommended by the standard. Through hierarchical analysis, it is known that above the transmission layer, if a common object model is established for various medical devices, they can be unified in function, and differences in interfaces and transmission protocols can also be shielded in the underlying communication. Therefore, this article designs the system hierarchy as shown in Figure 2.

2.3. Remote Information Access. It can be seen from the foregoing that the EVENT REPORT service is an implementation mechanism for the Agent to actively report device configuration information and measurement data. After the session is established, the Agent actively reports the detailed configuration information of the medical device to the Manager so that it can be identified [22]. The configuration service message describes the specific implementation of the MDS object and its subobjects, such as the types and handles of these objects. In order to reduce the size and quantity of message transmission between devices, save conversation time, optimize communication efficiency, and at the same time support the expansion of device functions, the standard document defines two device configurations: standard configuration and an extended configuration. When requesting to establish a session with the Manager, the Agent uses the configuration ID to fill in the session connection request message to maintain the session. The configuration ID in the Agent remains unchanged throughout the life cycle of the session connection. The fixed and unique configuration ID ensures that the attributes of the device MDS object and its subobjects are stable and unchanging.

Table 2 describes two types of configuration ID assignments. One is the ID of the standard configuration. For example, the standard configuration ID of a blood pressure meter is $0 \times 02BC$, and the standard configuration ID of a blood glucose meter is 0×0190. Their IDs are customized and fixed by the standard. In order to support the expansion of device functions, the other is the extended configuration ID, which requires an ID greater than 0×4000 and not related to a specific device. For example, the configuration ID of device A is 0×5123, and the configuration ID of device B is also 0×5123, but the Manager does not consider them with the same configuration, after establishing a session connection with the two devices, each of them needs to actively send their own device configuration information. During the session, the Agent may add or change the attribute values of some objects. At this time, the Agent must first release the session connection and then resend the session connection request message to establish a new session. When entering the configuration state, the Agent needs to send a new configuration report to the Manager again.

2.4. Data Configuration. To correctly collect the data generated by standard medical equipment, the Manager first needs the medical equipment to implement and send the

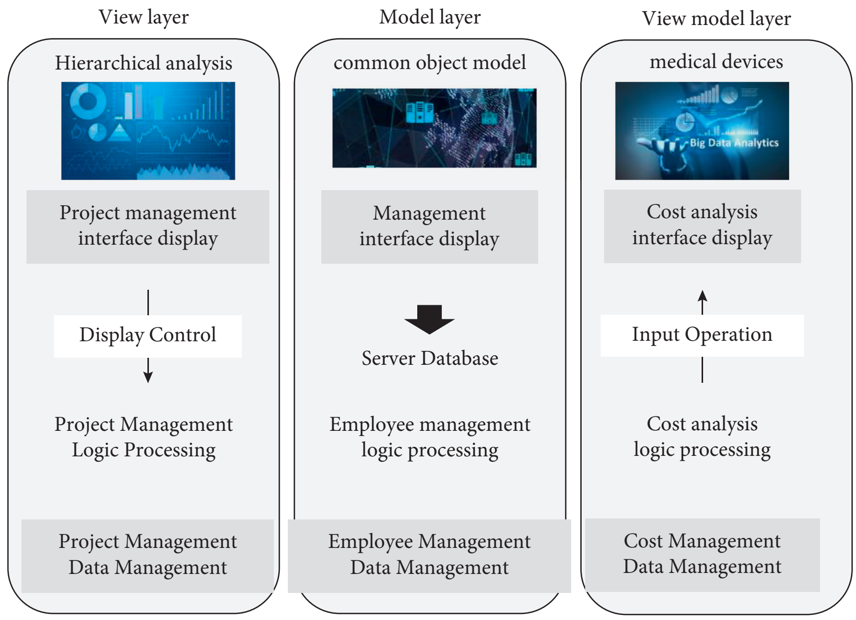

Figure 2: System hierarchy diagram.

Table 2: Assignment of device configuration ID.

Configuration type	Device information	Record time
The standard configuration	Sphygmomanometer	2021-xx-xx
	Blood glucose meter	2021-xx-xx
	Weight scale	2021-xx-xx
	Oximeter	2021-xx-xx
	Respirometer	2021-xx-xx
Expansion configuration	Exercise data	2021-xx-xx
	Sleep data	2021-xx-xx
	Other	2021-xx-xx

configuration information in the description document. As shown in the device configuration service process in Figure 3, when the Agent sends a session connection request to the Manager, the request message carries the configuration ID of the device. If the Manager supports the standard configuration of the ID, there is no need to send the EVENT REPORT configuration information report. Otherwise, the Agent needs to use EVENT REPORT to send. The configuration information report is an object attribute list that contains the attribute description information of all medical equipment objects and their subobjects. After the session is successfully connected and enters the operating state, the Manager will use the configuration information report or realize the existing standard configuration according to the standard requirements to create a domain information model to analyze the medical device. The domain information model created here is similar to that in the Agent just for easy analysis. All data in the domain information model come from the Agent, and all event reports generated by changing actions are also generated due to changes in the attribute values in the Agent object.

The extended configuration may have multiple formats when it is implemented. For this reason, the Manager must be able to correctly identify the specific objects and their attributes in these domain information models during the configuration phase. Once identified, it will save the current configuration information in order to skip the operation of this stage in the future conversation process, which can save the number of messages and optimize the communication efficiency. This optimization is only for the specified device. If there is another device with the same manufacturer information and object model, for example, devices A and B have the same configuration ID at the same time, they do not share the same configuration information. At this time, A and B devices have different system IDs, requiring them to send their own configuration information; otherwise, the Manager will not be able to recognize them. Although the implementation of the standard configuration can bring many advantages, medical equipment occupies less memory and communication becomes simple, reduces costs, and can extend the battery life to a certain extent. However, to effectively support the expansion of device functions, an extended configuration must be used. For example, the standard configuration of the oximeter does not support the persistent storage measurement mechanism, and a useful oximeter should support it by using the extended configuration. This persistent storage measurement mechanism can bring a lot of convenience to users and can ensure that the Agent can temporarily store multiple copies of measurement data when the Manager is not connected. Once connected to the Manager, the temporarily stored data can be transferred.

Recommendation accuracy is the most used evaluation indicator, that is, the degree of agreement between the recommendation system's predicted score (or ranking) and the user's actual score (or ranking), which is mainly divided into three categories: prediction accuracy, classification accuracy, and ranking accuracy. The specific calculation formula of the evaluation index is as follows:

Mean Absolute Error (Pc):

$$P_c(Q) = P_i(Q). \quad (1)$$

Mean Square Error (C):

$$C(I) = \frac{P_i(Q) \cap R_Q(I)}{Q(x)}. \quad (2)$$

Root Mean Square Error (a):

$$a(I) = \frac{|P_i(Q) \cap R_Q(I)|}{U}, D \leq 1. \quad (3)$$

Standard mean absolute error (p):

$$p_i(x, y) = a_i * b_i(y) \bigcup b_{i(x)}. \quad (4)$$

In the formula, N is the number of objects that the user has rated, $\{p_i\}$ is the set of user predicted scoring values, and $\{r_i\}$ is the set of users' actual scoring of the objects.

Consider that there will also be a naming conflict problem; that is, objects of the same nature may have multiple different names, but they are essentially similar, but this type of recommendation algorithm cannot find and use this similarity. In response to these problems, model-based collaborative filtering recommendation algorithms have become an inevitable choice to replace traditional collaborative filtering recommendation algorithms. Among them, traditional matrix factorization (MF) technology is widely used. The following article will elaborate on the SVD decomposition method in the traditional matrix decomposition technology. Singular Value Decomposition (SVD) is a generalization of eigenvalue decomposition on arbitrary matrices. Since the user-object scoring matrix is not necessarily a square matrix, the matrix decomposition method can be introduced into the recommendation system to achieve the purpose of reducing the dimensionality of the scoring matrix. This method assumes that R is an $M \times N$ matrix, which can be decomposed into the product of the following three matrices:

$$q_i(x, y) = a_i * b_i(y) \cap b_{i(x)}, \quad (5)$$

where U is an $M \times M$ square matrix (the vector of the square matrix is orthogonal and is called the left singular vector), $\sum$ is an $M \times N$ matrix (except for the diagonal elements, the rest are all 0 and sorted in descending order), VT It is an $N \times N$ square matrix (the vectors of the square matrix are orthogonal and are called right singular vectors). First, finding the eigenvalues, you can get the following:

$$p_i(x, y) = 0, a_i 2 = b * b_i(x), \quad (6)$$

where v is the right singular vector. In addition, you can also get the following:

$$p_i(x, y) = 0, a_i = 0. \quad (7)$$

Among them, σ is the singular value and u is the left singular vector. According to the existing relevant mathematical knowledge, the value of σ decreases very quickly, as shown in Figure 4.

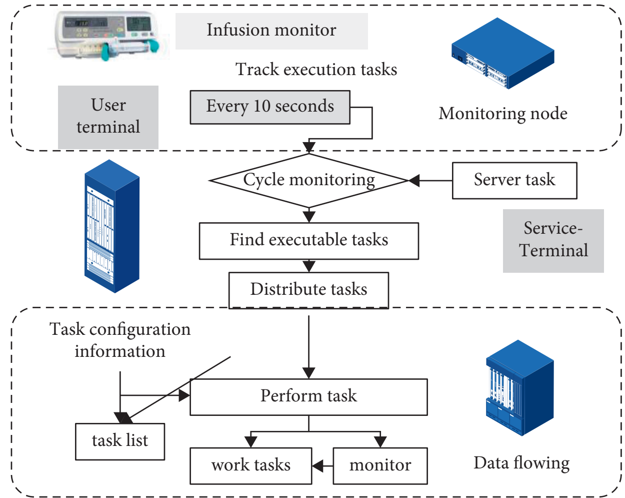

Figure 3: Device configuration service process.

3. Results and Analysis

3.1. Evaluation of Telemedicine Collaborative Service. In the actual decision-making method for evaluating the quality of telemedicine collaborative service, in order to judge the quality of public medical service, hospitals usually contact patients or family members and familiar people through different channels and methods to evaluate the doctor's telemedicine collaborative service quality, as shown in Figure 5. For example, for patients receiving telemedicine services, hospitals often receive evaluation information by directly asking the patients.

Hospital A is a comprehensive hospital. Through the cooperation of telemedicine collaborative services with specialized hospitals in developed areas, the hospital conducts telemedicine collaborative service quality assessments for medical personnel who are specifically responsible for telemedicine collaborative service operations to monitor the overall telemedicine collaborative service level and continuously improve the effect and efficiency of telemedicine collaborative services, as shown in Figure 6. The hospital selects ten medical personnel $X = \{x_1, x_2, .., x_{10}\}$, who are responsible for the operation of telemedicine collaborative services as the evaluation objects, and invites 100 evaluators from different sources, for example, patients undergoing treatment and those who have been discharged. For patients who make appointments online and their family members are waiting for treatment, their set is $Q = \{q1, q2, .., q10\}$.

As shown in Figure 7, the difference between the result according to the proposed method and the result that takes into account only the evaluation value can be analyzed. The two-dimensional average of 9x and 10x for medical personnel is high, but one of the dimensions is too low for 3x and 4x. As the saying goes, we know that the amount of water a bucket can absorb depends on the shortest plank. In this case, the total rating of nine and ten times as high as that of medical personnel is inevitably affected. However, in the proposed method, this two-dimensional balance is taken into account by the evaluation value and it can be seen that

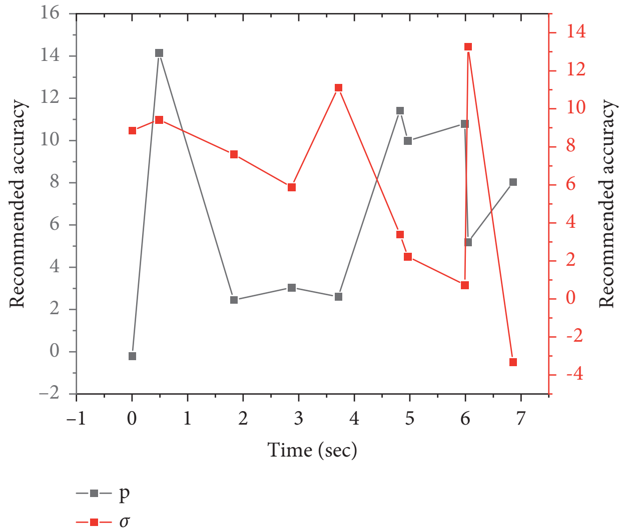

Figure 4: Recommended accuracy of the telemonitoring system.

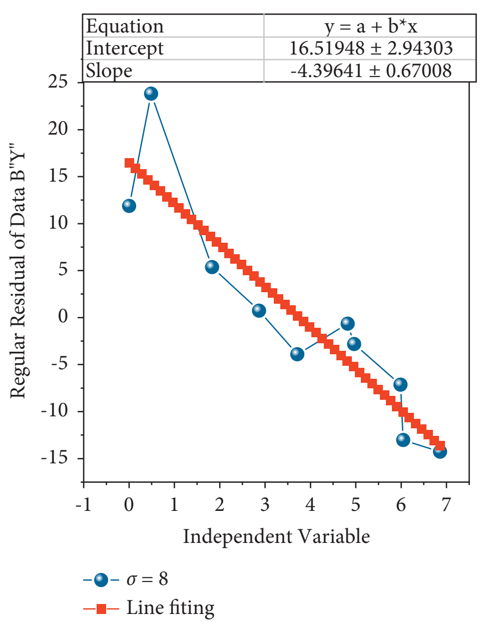

Figure 5: Telemedicine collaborative service quality.

the ranking of the medical staff is nine times and ten times higher. For the same reason, see 3x, 4x, 1x, 9x of the medical staff. Taking into account the balance of the two dimensions, we can achieve more precise alternative results. The above calculation combines an evaluation model based on the random MULTIMOORA method with a common evaluation of the multisource telemedicine service quality. This study will improve existing telemedicine management in my country and avoid a unilateral dependence on medical evaluation. The dimensions for evaluating the level of collaborative services of medical staff in telemedicine are competence {R1} and reputation {R2}. The subattributes of

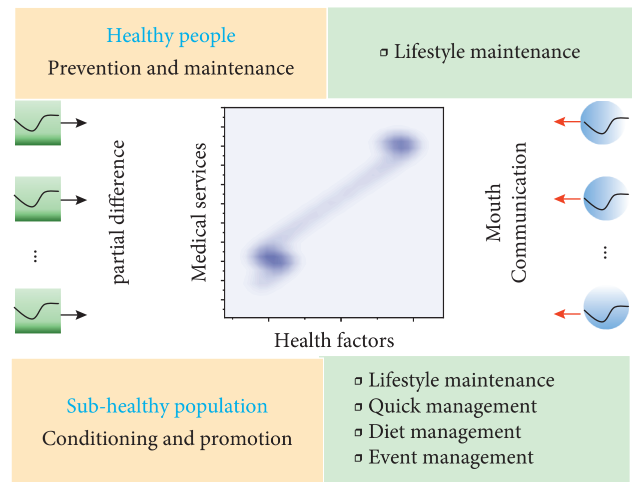

Figure 6: The efficiency of medical collaborative services.

the ability dimension are preliminary preparation {R11}, medical ability {R12}, efficiency {R13}, and error rate {R14}, while the subattributes of the reputation dimension are service attitude {R11}, responsibility {R21}, integrity {R31}, and communication skills{R41}.

4. Analysis of Experimental Results

In this text, we use the software to perform numerical simulation analysis of several parameters and intuitively analyze the effects of different states on the development results of game strategy selection via graphics. If the probability that a special hospital and a special hospital share knowledge is 0.6, both are on standby. The level of knowledge of a general hospital is at 60, and the level of knowledge of a general hospital is significantly higher than that of the general hospital. The reliability of general hospitals is as high as 0.1, and the reliability of specialized hospitals is 0.9. The degree of completeness of knowledge between the two parties is on average 0.8. The cost of the knowledge exchange of a specialized hospital is 0.2, which is significantly higher than that of 0.5 in a general hospital. The level of government incentives and penalties for specialized hospitals is also higher than that of regular hospitals. The initial value of a certain parameter is shown in Figure 8.

The impact of changes in the degree of knowledge complementarity on the system is shown in Figure 9. After the session is successfully connected and enters the operating state, the Manager will use the configuration information report or realize the existing standard configuration according to the standard requirements to create a domain information model to analyze the medical device. The domain information model created here is similar to that in the Agent just for easy analysis. Through our proposed method, the balance between the evaluation value and the two dimensions determines the quality of community telemedicine services.

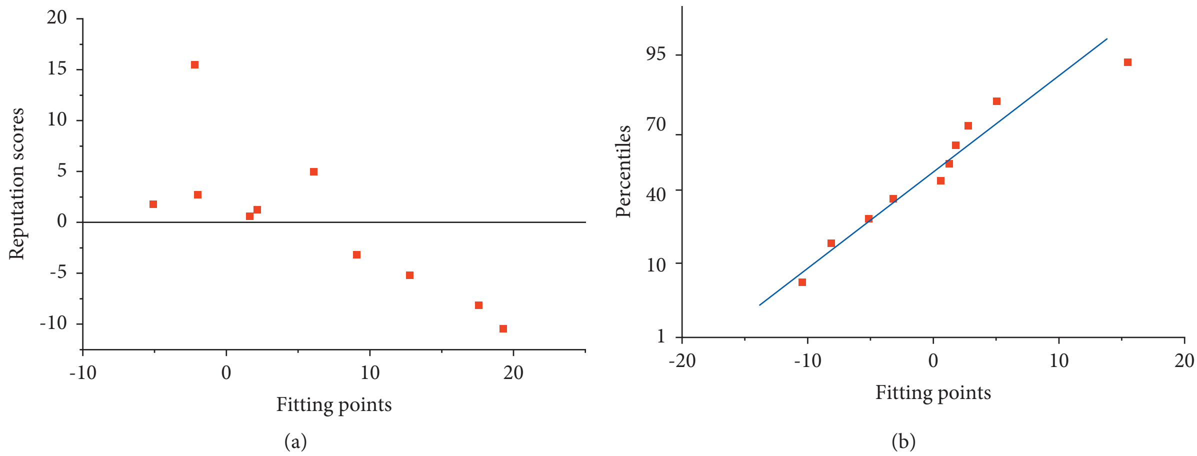

Figure 7: Ranking of reputation scores under comprehensive dimensions.

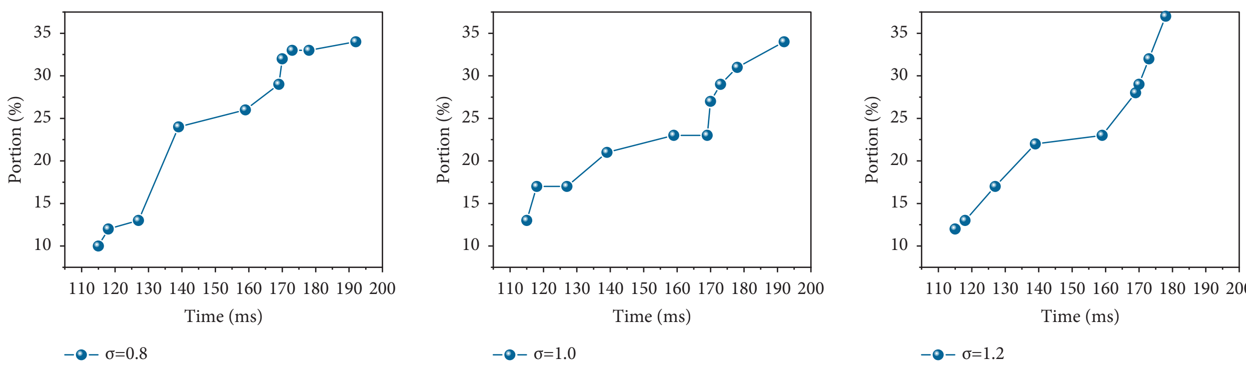

Figure 8: Parameter initialization value table.

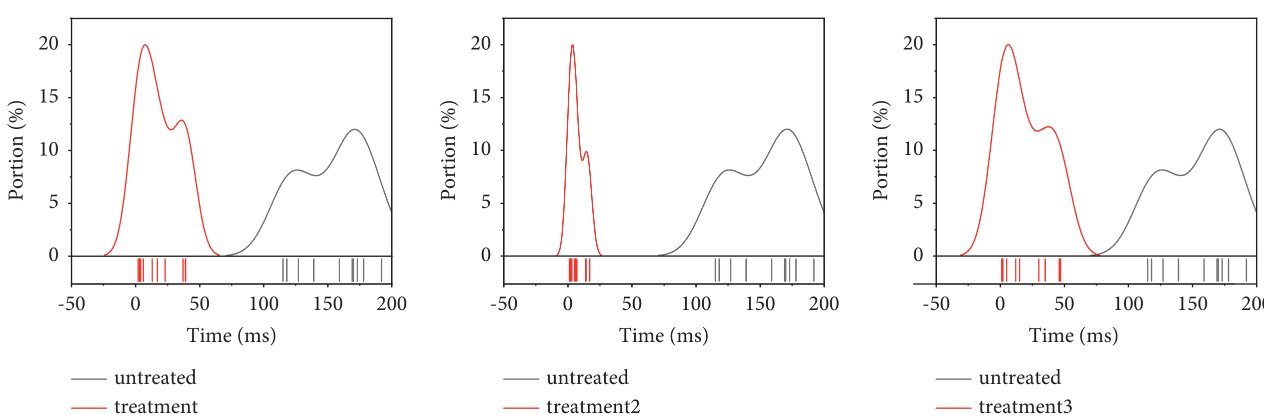

Figure 9: The impact of changes in the degree of knowledge complementarity on the system.

5. Conclusion

There are huge compatibility issues between medical equipment and medical data collection systems. There are many types of equipment, and the interaction protocols and data formats between the equipment are also inconsistent. This makes it difficult to collect different types of medical health with the same system in the home environment data. This article puts forward the research direction of the subject based on actual problems, mainly researching and implementing the IEEE 11073 standard protocol and then designing and implementing a collection and transmission system according to home application scenarios. The system is mainly divided into acquisition converter and client software. After using the IEEE 11073 standard protocol, it can be compatible with the access of blood pressure meters, blood glucose meters, blood oximeters, and weight scales and can realize automatic data acquisition. The system has good practicability and promotion significance. The configuration information report is an object attribute list that contains the attribute description information of all medical equipment objects and their subobjects. The use of communication plug-ins solves the needs of multiple communication transmissions. This article implements two transmission plug-ins: Bluetooth and TCP/IP. The transcoding plug-in chooses the realization of the oximeter to explain how to transcode medical equipment, including connecting medical equipment and converting the original custom data format into data that conform to the IEEE 11073 format. In this way, even nonstandard medical equipment can be integrated into the system, thus solving the compatibility problem.

Data Availability

All data, models, and code generated or used during the study appear in the submitted article.

Conflicts of Interest

The authors report no potential conflicts of interest.

Acknowledgments

The study was funded by the Key R & D and extension projects in Henan Province (202102210177).

References

[1] J. Shi, L. Quan, X. Zhang, and X. Xiong, "Electro-hydraulic velocity and position control based on independent metering valve control in mobile construction equipment," *Automation in Construction*, vol. 94, pp. 73–84, 2018.

[2] Z. Zhu, M.-W. Park, C. Koch, M. Soltani, A. Hammad, and K. Davari, "Predicting movements of onsite workers and mobile equipment for enhancing construction site safety," *Automation in Construction*, vol. 68, pp. 95–101, 2016.

[3] Y.-T. Tai, C.-H. Huang, and S.-C. Chuang, "The construction of a mobile business application system for ERP," *Kybernetes*, vol. 45, no. 1, pp. 141–157, 2016.

[4] P. K. Mvemba, S. K. Guwa Gua Band, A. Lay-Ekuakille, and N. I. Giannoccaro, "Advanced acoustic sensing system on a mobile robot: Design, construction and measurements," *IEEE Instrumentation and Measurement Magazine*, vol. 21, no. 2, pp. 4–9, 2018.

[5] T. O. Osunsanmi, A. E. Oke, and C. O. Aigbavboa, "Survey dataset on fusing RFID with mobile technology for efficient safety of construction professionals," *Data in Brief*, vol. 25, pp. 104290, 2019.

[6] C. Chen, L. Tang, C. M. Hancock, and P. Zhang, "Development of low-cost mobile laser scanning for 3D construction indoor mapping by using inertial measurement unit, ultra-wide band and 2D laser scanner," *Engineering Construction and Architectural Management*, vol. 26, no. 7, pp. 1367–1386, 2019.

[7] L. Hu, "The construction of mobile education in cloud computing," *Procedia Computer Science*, vol. 183, pp. 14–17, 2021.

[8] S. Douzi, F. A. AlShahwan, M. Lemoudden, and B. E. Ouahidi, "Hybrid email spam detection model using artificial intelligence," *International Journal of Machine Learning and Computing*, vol. 10, no. 2, pp. 316–322, 2020.

[9] S. Sheikhi, M. T. Kheirabadi, and A. Bazzazi, "An effective model for SMS spam detection using content-based features and averaged neural network," *International Journal of Engineering*, vol. 33, no. 2, pp. 221–228, 2020.

[10] E. W. M. Lee and H. F. Lam, "Intelligent-based structural damage detection model," *Mechanics of Advanced Materials and Structures*, vol. 18, no. 8, pp. 590–596, 2011.

[11] R. Nabati and H. Qi, "CenterFusion: Center-based radar and camera fusion for 3D object detection," in *2021 IEEE Winter Conference on Applications of Computer Vision (WACV)*, pp. 1526–1535, Waikoloa, HI, USA, 3-8 Jan. 2021.

[12] J. Guo, X. Xing, W. Quan et al., "Efficient center voting for object detection and 6D pose estimation in 3D point cloud," *IEEE Transactions on Image Processing*, vol. 30, pp. 5072–5084, 2021.

[13] S. Xia, M. Liu, C. Wang et al., "Inhibition of SARS-CoV-2 (previously 2019-nCoV) infection by a highly potent pan-coronavirus fusion inhibitor targeting its spike protein that harbors a high capacity to mediate membrane fusion," *Cell Research*, vol. 30, no. 4, pp. 343–355, 2020.

[14] M. Mauthe, I. Orhon, C. Rocchi et al., "Chloroquine inhibits autophagic flux by decreasing autophagosome-lysosome fusion," *Autophagy*, vol. 14, no. 8, pp. 1435–1455, 2018.

[15] A. Drilon, T. W Laetsch, S. Kummar et al., "Efficacy of larotrectinib in TRK fusion-positive cancers in adults and children," *New England Journal of Medicine*, vol. 378, no. 8, pp. 731–739, 2018.

[16] L. Liu, C. Chen, Q. Pei, S. Maharjan, and Y. Zhang, "Vehicular edge computing and networking: A survey," *Mobile Networks and Applications*, vol. 26, no. 3, pp. 1145–1168, 2021.

[17] J. Liu, W. Li, G. O. Karame, and N. Asokan, "Scalable byzantine consensus via hardware-assisted secret sharing," *IEEE Transactions on Computers*, vol. 68, no. 1, pp. 139–151, 2019.

[18] J. Liu, K. Au, A. Maaref et al., "Initial access, mobility, and user-centric multi-beam operation in 5G new radio," *IEEE Communications Magazine*, vol. 56, no. 3, pp. 35–41, 2018.

[19] Q. Zhang, M. Jiang, Z. Feng, W. Li, W. Zhang, and M. Pan, "IoT enabled UAV: Network architecture and routing algorithm," *IEEE Internet of Things Journal*, vol. 6, no. 2, pp. 3727–3742, 2019.

[20] D. Zhang, Y. Liu, L. Dai, A. K. Bashir, A. Nallanathan, and B. Shim, "Performance analysis of FD-NOMA-based decentralized V2X systems," *IEEE Transactions on Communications*, vol. 67, no. 7, pp. 5024–5036, 2019.

[21] M. Al-khafajiy, T. Baker, C. Chalmers et al., "Remote health monitoring of elderly through wearable sensors," *Multimedia Tools and Applications*, vol. 78, no. 17, pp. 24681–24706, 2019.

[22] J. Navarro-Ortiz, P. Romero-Diaz, S. Sendra, P. Ameigeiras, J. J. Ramos-Munoz, and J. M. Lopez-Soler, "A survey on 5G usage scenarios and traffic models," *IEEE Communications Surveys & Tutorials*, vol. 22, no. 2, pp. 905–929, 2020.