Design of telemedicine information query system based on wireless sensor network

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Abstract

INTRODUCTION: A wireless sensor network-based remote medical information query system is proposed and designed.
OBJECTIVE: The proposed method aims at improving the throughput of the hospital information remote query system and reducing the response time
METHODS: The system structure is divided into three levels. The presentation layer is responsible for displaying the query operation interface of the function layer. The function layer realizes the query function according to the user instructions. The wireless sensor network is responsible for the transmission of instructions. The data layer starts the query of telemedicine information based on the Top-k query algorithm. In wireless sensor networks, the improved ant colony algorithm is used to optimize it, which improves the information transmission performance of the system.
RESULTS: The experimental results show that the designed system can complete the medical information query according to the needs of users, the system throughput and the residual energy of sink nodes are high, and the maximum response time of the system is always less than 0.5s.
CONCLUSION: It shows that the designed system has strong practical application performance and high application value.

Keywords: Wireless sensor network; Telemedicine; Information Service; Information self integration.

Received on 27 April 2022, accepted on 04 August 2022, published on 04 August 2022

doi: 10.4108/eetpht.v8i4.674

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1. Introduction

Although telemedicine integrates modern communication, computer, medical and other technologies, it is not a recent invention. In a broad sense, telemedicine is the use of remote communication technology and computer multimedia technology to provide medical information and services, which includes all medical activities such as remote diagnosis, remote consultation and nursing, distance education, and remote medical information services [1]. In a narrow sense, telemedicine refers to medical activities such as remote imaging, remote diagnosis and conference, and remote nursing [2]. The development of this field in foreign countries has a history of nearly 40 years, but only a few years in my country.

With the rapid development of network communication and modern information technology, it has become a common phenomenon that many information management depends on computers. It is precisely because of the continuous renewal of technology that it brings a good opportunity for telemedicine, a brand-new treatment method. Telemedicine is a new treatment method based on network technology and combined with traditional medical technology to realize online treatment [3].

Telemedicine information query system is different from other medical information systems. It focuses on using information to serve people and provide decision-making, so that people can get the needed information conveniently, quickly and comprehensively [4]. As an important part of medical information system, medical information query system is an information system for the acquisition, storage, management and query of various medical data closely related to diagnosis and treatment [5]. At present, most of the medical information systems are set up for hospitals, ignoring the practical needs of the broad masses of the people. People can not understand their own situation and the situation of hospitals and drugs before seeing a doctor. The telemedicine information query system is to make up for the shortcomings of current medical information, better serve the people and enhance the practicability of the medical information system [6]. The integration and information sharing among various heterogeneous medical information systems is the theme of the development of medical information systems in the future. The communication standards and medical data standards between systems are particularly important [7]. At present, in the system, for example, electronic medical record is a record of all medical activities of patients. The sharing of electronic medical record is only limited to medical personnel and does not realize extensive and complete sharing, resulting in the non sharing of information resources and the serious phenomenon of information island [8]. Therefore, it is imperative to establish a medical information system that is not only suitable for medical personnel, but also can provide information sharing for non-medical personnel [9].

According to the current situation of the medical industry, the number of drugs will double almost every 15 years. Coupled with the development of old ingredients and new preparations, new drugs are constantly studied and put into clinical application. Some old drugs also have new uses and adverse effects. Secondly, hospital information, such as the adjustment of hospital personnel, the change of level and the adjustment of main treatment, is changing all the time. In addition, medical information is constantly updated and changing, which makes people's demand for this information more and more urgent. Such changes are bound to lead to the incomplete provision of content and the failure to find some of the required information. The existing touch screen system of hospital information is a closed system, which is limited to some simple information existing in the hospital, and there is basically no update. Therefore, the medical information system must be an open, extensible and modular system to adapt to the real-time changes of medical information.

The amount of data of medical information is huge, and the data is redundant and inconsistent, so that a large amount of data accumulated by the system can not be used effectively. At present, most medical information systems only deal with information in the transaction processing stage, which can only meet the specific daily management needs of managers, and lack tools to extract valuable knowledge from massive data [10]. Therefore, reasonably integrating the existing medical information resources, giving full play to the advantages of information resources, processing and analyzing these expensive collected data and transforming them into the information needed for medical decision-making is an important problem faced by medical services [11]. In addition, what we are most concerned about is that these current medical information systems either only serve hospitals and are used for hospital information management ; Or it is only used for drug information retrieval. Therefore, the level of medical information integration is not high, the data has not been fully shared, and the hospital has not established a direct connection with the drug data, this leads to "information island". Although a large amount of data has been accumulated, there is a lack of effective means to find the important information hidden in the data for decision-making. UMLS (Unified Medical Language System) is an integrated language system researched and developed by the United States since 1986. According to relevant research results, Safaei improves the sorting quality of medical texts through image retrieval [12]; Information retrieval is used to improve the accuracy of corresponding information classification. This system combines intelligent information retrieval technology [13], can realize cross database retrieval. It can help users to connect information sources, including computerized medical records, bibliographic databases, and electronic biomedical information in fact databases for integrated retrieval. Although the above two systems can complete information retrieval, with the increase of the amount of data, the throughput of the above two systems is difficult to meet the requirements of the increasing telemedicine information, and the response time of the system is long.

Based on the above research results, combined with the characteristics of Telemedicine Information Retrieval and query, a telemedicine information query system based on wireless sensor network is proposed and designed. The overall research scheme of the system is:

Firstly, the hardware part of the system designs wireless sensor network, embedded gateway and medical information database to realize the transmission and query of telemedicine information.

Secondly, the software part of the system uses the medical information self-integrated information retrieval method based on the Top-k query algorithm to retrieve the medical information required by users in the database and feed it back to users. The system uses the wireless sensor network routing optimization method based on the improved ant colony algorithm to optimize the network transmission performance of the system.

Finally, taking the throughput and response time as the comparison indicators, the comparison and verification experiments are carried out.

The innovation points are as follows: the wireless sensor network is used for telemedicine information retrieval to avoid query errors. It can help system users query telemedicine information quickly and accurately, and make telemedicine services more transparent and standardized. It is a query system with strong application performance.

2. Telemedicine information query system based on wireless sensor network

2.1. Hardware design

As shown in Figure 1, the organizational structure of Telemedicine Information Query System Based on wireless sensor network is composed of wireless sensor node, embedded gateway, wireless sensor network and client. Wireless sensor network is used to send data through sink node of network coordinator. Sink node transmits the data to the embedded gateway in real time through RS-232 serial port bus. The embedded network receives, analyzes and processes the information sent by sink node, sends it to the local embedded database for storage or transmits it to the remote client through the network, and answers the query from the user. This kind of query mode eliminates the frequent information confirmation time during user query and avoids the problems such as network congestion caused by the simultaneous transmission of a large number of sensing information [14], so it has strong real-time performance.

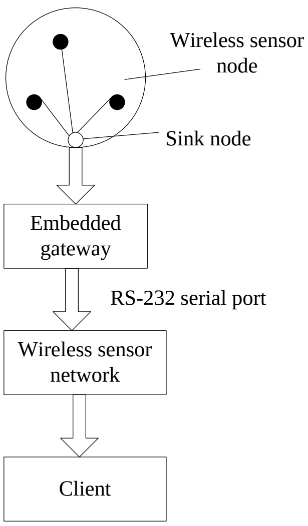

Figure 1. Organization structure of Telemedicine Information Query System Based on Wireless Sensor Network

Figure 2 shows the internal architecture of the system:

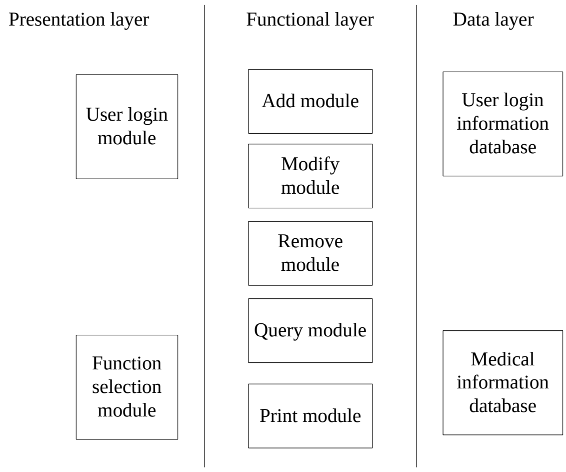

Figure 2. Internal structure of Telemedicine Information Query System Based on Wireless Sensor Network

As shown in Figure 2, the internal structure of Telemedicine Information Query System based on wireless sensor network is mainly divided into presentation layer, function layer and data layer. The presentation layer includes user login module and function selection module as the interface of human-computer interaction. The function layer includes functional modules such as information addition, modification, deletion, query and printing. The data layer includes user login information database and medical information database.

(1) Wireless sensor network

Wireless sensor network (WSN) is composed of a large number of cheap micro sensor nodes deployed in the monitoring area [15-18]. It is a multi hop self-organizing network system formed by wireless communication. Its purpose is to sense, collect and process the information of perceived objects in the network coverage area cooperatively, and send it to the observer.

Wireless sensor network is composed of sensor node, transmit node and sink node. The specific structure is shown in Figure 3. A large number of sensor nodes are randomly deployed in or near the sensor field. The sensor nodes enter the wake-up state of self-test startup. Under the guidance of the cluster head node, the routing topology is established. Then the sensor nodes collect and record medical information and transmit medical information hop by hop along the previously established routing topology path. In the transmission process, the data may be processed by multiple forwarding nodes and transmitted to the sink node after single hop or multi hop routing. The sink node transmits the medical information data to the gateway node for centralized processing through wired mode. The dotted line between nodes represents the wireless communication line conforming to 802.15.4 standard. From the perspective of network function, each forwarding node has the dual functions of medical information monitoring and routing. In addition to local information collection and data processing, it also needs to store, manage and integrate the medical information data forwarded by other nodes, and cooperate with other nodes to complete some specific tasks[21-22].

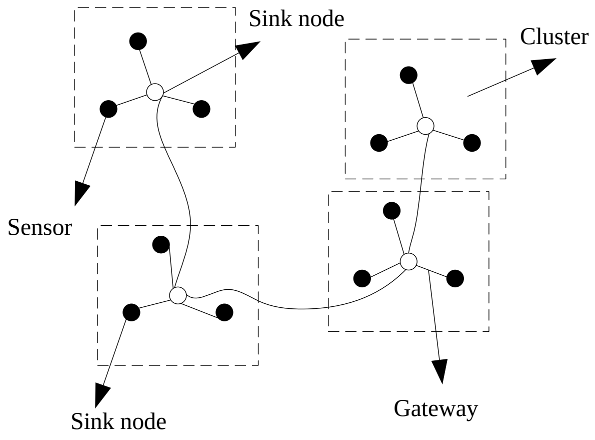

Figure 3. Wireless sensor network structure

(2) Embedded gateway

The embedded gateway device is composed of a core board and a backplane. The core board integrates AT91RM9200 processor, 64M SDRAM and 16m FLASH. AT91RM9200 processor chip is an industrial 200MIPSARM920T core with 16K bytes of instructions and 16K bytes of data cache. It has 128K bytes of read-only memory inside. The external bus includes SDRAM interface, Burst Flash interface and SRAM controller, USB device and main controller interface, 10/100M Ethernet interface, power manager, real-time clock, system clock, synchronous serial controller, 6-channel timing counter, 4-channel USART, two-wire interface, SPI interface, multimedia card interface, GPIO, etc. AT91RM9200 processor chip is a multi-user general chip. It integrates microprocessors and common peripheral components, and has high cost performance.

The backplane of gateway equipment provides the following external interfaces: two 4-wire RS232 serial ports and a 10M/100M adaptive Ethernet interface. The choice of peripheral hardware interface will determine how the whole system accesses the network. At present, the most common low-cost and efficient access method is to use the most mature Ethernet interface, which can meet the requirements of LAN access and most broadband network access. Therefore, the embedded gateway device designed in this paper is connected to the computer through Ethernet interface to realize the user's query of medical information. It connects with sink node through an RS232 interface to receive the information transmitted by wireless sensor network. In addition, a serial port is reserved as the interface to expand the wireless communication function in the future. The device has the characteristics of small volume, low power consumption and strong processing capacity.

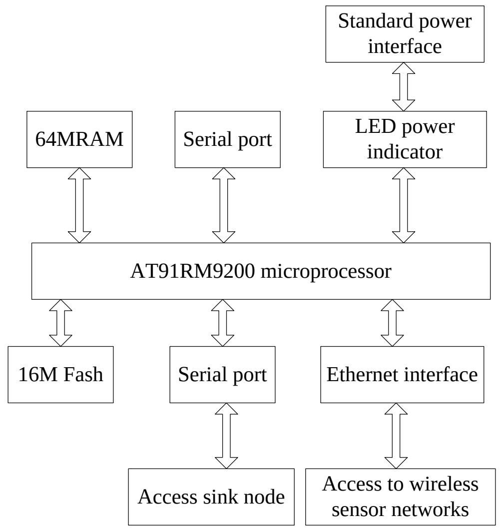

Figure 4. Hardware structure of Embedded Gateway

(3) Medical information database

At present, Oracle database has been widely used in management systems in many fields. Oracle uses the E-LT engine created based on Java, which is suitable for a variety of mainstream data sources of medical information, can seamlessly connect with Oracle database, and can meet the integration requirements of important medical information data. Therefore, the application type of medical information database in this system is Oracle database, as shown in Figure 5.

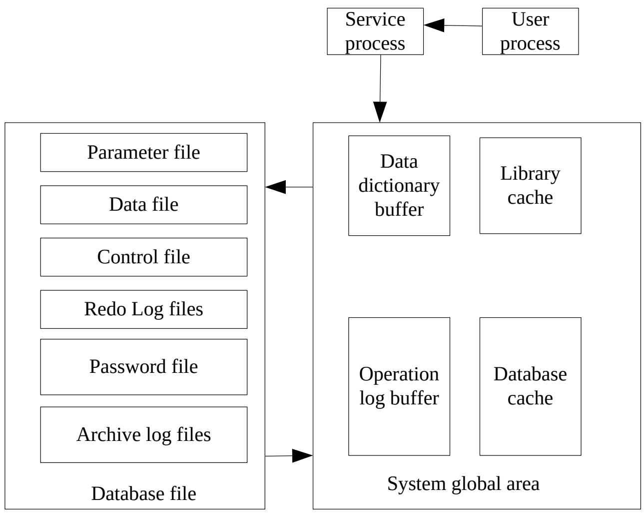

Figure 5. Structure of medical information database

The database consists of user process and instantiated object. Entering the user process means entering the global area of the system. Its medical information data can complete the information interaction with the database file, and the interactive medical information data can be completely stored in the buffer, which fundamentally improves the work efficiency of the database.

2.2 System software design

2.2.1Self-integration information retrieval of medical information based on Top-k query algorithm

Top-k query algorithm is one of the most commonly used query methods. When retrieving the records in the medical data set through Top-k query algorithm, users can set the weights of different attributes to reflect their own preferences, while the system estimates the weights submitted by users and matches them according to the estimated weights to return the first x results that meet the needs of the user. Top-k query can help users get the required information from a large number of medical information data. It can obtain the retrieval results without querying all records, and the retrieval efficiency is high. In this study, the Top-k query algorithm is used to allocate the reliability of telemedicine information and obtain the semantic results of medical information, so as to realize the self-integrated information rapid retrieval of telemedicine information.

Self-integration information retrieval refers to the process of finding the required self-integration information from a large number of medical information. The commonly used retrieval models of self-integration information include Boole model, spatial vector model, probability model and text model. Based on the Top-k query algorithm, the model in this paper carries out self-integration information retrieval of medical information. Assuming that the framework of Top-k query algorithm of medical integration information is $\theta = \{similar, \ dissimilar, \ unable\ to\ confirm\}$, the rapid retrieval model $n(B)$ of medical self-integration information can be described as the following basic reliability allocation:

$$n(B)=\begin{cases} Sc(a,b), B\ means\ similar \\ 0,\ B\ means\ dissimilarity \end{cases} \tag{1}$$

Where, $Sc(a,b)$ represents the similarity calculation result in the retrieval method corresponding to medical information.

The Markov chain method for calculating the probability of event occurrence is used to measure the importance of word meaning in medical self-integration information. It mainly uses the current original state probability value and state change probability matrix of medical information to verify the future situation of traditional Chinese medicine information in the medical information database. The steps are as follows:

(1) Determination of the original state probability vector J_0 of medical information: that is, to determine the original probability of each word meaning in the self-integration information of medical information in the retrieval process. The equation is:

$$J_0=\left(\frac{1}{N},\frac{1}{2N},...,\frac{1}{MN}\right) \tag{2}$$

Where, N is the amount of information with different types in medical self-integration information; M indicates the M-th medical information.

(2) Matrix for calculating the change probability of medical information status: according to the created word map, the simultaneous occurrence matrix of words in medical self-integration information can be obtained, and then the probability change matrix Q_{ab} between words can be obtained according to the matrix:

$$Q_{ab}=\begin{cases} m_{a,b}J_0 / \sum_{b=0}^{M} m_{a,b}J_0, & a\neq b \\ 0, & a=b \end{cases} \tag{3}$$

Where, $m_{a,b}$ represents the number of simultaneous occurrences of a and b in medical integration information. Considering the relationship between the number of occurrences of word meaning in the same position, the method similar to the method of mixing damping factor in PageRank algorithm is used to change equation (3) to:

$$Q'_{ab}=\begin{cases} \dfrac{\Phi}{J_0}+\dfrac{m_{a,b}-m_{a,b}\eta}{\sum_{b=0}^{J_0=1} m_{a,b}J_0}, & a\neq b \\ \dfrac{\Phi}{m_{a,b}J_0}, & a=b \end{cases} \tag{4}$$

Where, Φ and η are the damping factor and weight in turn.

(3) Determination of the importance of words when users retrieve medical information: the probability in the state probability vector can be obtain by constraining, and it is used to calculate the importance of word meaning in medical self-integration information. The equation is:

$$DF(cv_j,\eta)=CJ_jJ_0\Phi \tag{5}$$

Where, j is the subscript of word meaning in medical self-integration information cv_j ; CJ_j is the probability corresponding to the meaning of the j-th word in the constrained vector.

Based on the above steps, the fast retrieval method for the self-integration information of medical information based on Top-k query algorithm is completed.

2.3.2 Routing optimization method for wireless sensor networks based on improved ant colony algorithm

In the wireless sensor network used in the system of this paper, all nodes generate services and send packets to the sink node, so as to form many to one transmission. For various network topology models, they can be regarded as the network topology model having multi hop hierarchical tree with Sink node as the center. When querying telemedicine information, for a node j, it can set its child node set to $D(j)$ and its parent node is set to $Q(j)$. Figure 6 is a wireless sensor network model. Nodes 5, 6 and 7 are the child nodes of node 2, and node 0 is the parent node of node 2. There may be two types of medical information traffic in each node: the source traffic generated locally and the medical information traffic forwarded for child nodes.

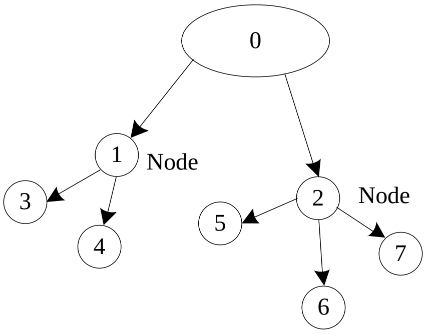

Figure 6 Wireless sensor network model

When defining the medical information query, the source service rate is s_r^j and the forwarding service rate is s_{hs}^j. The two converge to form the total input rate s_{jm}^j. When s_{jm}^j exceeds the packet transmission rate s_g^j, the medical information service packet will form a queue in the buffer. When s_{jm}^j is larger than s_g^j, the buffer of node j will be filled up and will eventually overflow.

The digital features of cloud model can be expressed by three values: expected value Fy, entropy Fn and super entropy Kc, which constitute qualitative and quantitative mutual mapping, and serve as the basis of medical information knowledge representation. The primary mapping from qualitative concept to quantitative concept forms a cloud drop, and its formation process is uncertain. The cloud model gives the certainty β of cloud drop to qualitative concept. According to the generation mechanism and computing direction of cloud, there are forward cloud and reverse cloud. The forward cloud is divided into basic cloud, P -condition cloud and Q-condition cloud. The cloud generation algorithm can be realized in software or solidified into hardware, which becomes cloud generator DF.

One of the most important cloud models, the normal cloud model, has good mathematical properties such as randomness and stability tendency. Adding it to the optimization process of intelligent algorithm can ensure the diversity of individuals, achieve a good balance between exploration and development, and enhance the robustness of the algorithm.

In order to fully tap the parallelism of ant colony algorithm and the excellent characteristics of distributed computing, and reflect the complexity of real ant society, the current research focus turns to the multi ant colony algorithm of multi colony cooperative. The algorithm uses positive and negative pheromone effects and uses the interaction between groups to search multiple paths from the source node to the destination node to realize the multi-path routing mechanism.

The ants in the network are divided into forward ants and backward ants, and the taboo table of ants is initialized. The forward ants collect node information and locally update the pheromone. After reaching the destination node, the collected path information is transferred to the backward ants, and the backward ants globally update the path in the process of returning to the source node.

When querying telemedicine information, it is necessary to fully mine the telemedicine data in the Internet of things [20]. In order to improve the accuracy of data mining, ant colony algorithm is used to optimize the routing of wireless sensor networks. Let B_j^h represent the j-th ant agent in wireless sensor network population h, and the ants in this population release the same type of pheromone; Different populations release different types of pheromones. The ant that sets the population h is currently located in the wireless sensor node j, and selects the attraction factor Ω_j of the h-type pheromone of the next node i in its neighborhood δ_{ji}^h:

$$\delta_{ji}^h = \alpha_{ji}^h B_j^h / \sum_{k\in\Omega_j} \alpha_{ji}^h B_j^h \tag{6}$$

Where α_{ji}^h is the pheromone concentration; k is the domain node.

The ant of population h is currently located at sensor node j and selects the rejection factor ε_{ji}^h of the h-type pheromone of the next node i in its neighborhood Ω_j:

$$\varepsilon_{ji}^h = \sum_{k\neq s} \alpha_{ji}^h B_j^h / \sum_{k\in\Omega_j} \alpha_{js}^h B_s^h \tag{7}$$

Where α_{js}^{h} represents the pheromone concentration of the s-th ant B_{s}^{h} in the neighborhood.

When the ant at node j selects the next sensor node i according to the probability transfer rule in its field Ω_j, the ant will choose the path with higher pheromone concentration of its own type with higher probability. Due to the repulsion of different pheromone concentrations, the ant will choose the path with higher pheromone concentration from other groups with lower probability. The transition probability of the ant at sensor node j in the population R when selecting the next node i for routing is $W_{ji}^{R}(h)$.

In the multi ant colony algorithm, pheromone residue coefficient ϕ and pheromone strength V are important parameters to control randomness. The cloud droplets generated by the cloud generator are used to adjust the sizes of ϕ and V. For pheromone residue coefficient ϕ, the randomness is strong when taking a smaller value, and weak when taking a larger value, while strong randomness is conducive to global search, and weak randomness is conducive to local search. Therefore, in the multi ant colony algorithm, the raised semi normal cloud rule is used to control ϕ and V. That is, the P condition cloud of the multi rule generator is realized by using the residue coefficient ϕ and time t of the pheromone before adjustment as input parameters, and the Q condition cloud of the multi rule generator is realized by using the pheromone intensity cloud and the adjusted pheromone residue coefficient cloud.

In the application of large-scale wireless sensor networks, a large number of remote medical query information and data are transmitted through a specific path to the Sink node. It is easy to form a network hotspot area near the base station node, which may lead to serious network congestion or even congestion collapse due to excessive node load. The neighbor nodes within the hop range of sink nodes are regarded as child Sink nodes, while other sensor nodes can communicate with Sink nodes only through child Sink nodes. The steps of routing optimization algorithm for multi ant colony based on cloud model are as follows:

(1) Algorithm initialization

There are n ants in each population. Each ant carries information such as ID number of population, ID number of source node, ID number of passing nodes, timestamp, an empty stack, node load Z_j and success rate QSS_j of data packet.

(2) The attraction factor and repulsion factor of pheromone

In telemedicine information query, when the ant at node j selects the next sensor node i according to the probability transfer rule in its neighborhood Ω_j, the ant will choose the path with higher pheromone concentration of its own type with higher probability.

(3) Probability transition rule

The heuristic function γ_{ji} comprehensively considers the measurement parameters such as single hop delay, hops, node queue length and packet arrival success rate, and its expression is:

$$\gamma_{ji} = s_{hs}^{j}\left(QSS_j / Z_j E_{ji} KD_i\right) \tag{8}$$

Where, the load of node i is Z_j; The single hop delay from node j to node i is E_{ji}; The number of hops from node i to sink node is KD_i.

(4) Local updating strategy of pheromone of forward ant

In telemedicine information query, the pheromone released by sensor nodes is different in different populations. The forward ant in the population transfers to the next node according to the pheromone of the population, and the updated pheromone is $\alpha_{ji}^{h}(t+m)$. Then:

$$\alpha_{ji}^{h}(t+m) = W_{ji}^{R}(h)\phi \times \alpha_{ji}^{h}(t) + \Delta\alpha_{ji}^{h} - \left(\Delta\alpha_{ji}^{h} \text{-} \phi\right) \tag{9}$$

Where $\Delta\alpha_{ji}^{h}$ is the pheromone mean. The pheromone residue coefficient needs to be selected by using the qualitative association rules of the ascending semi normal cloud model. The update mode of ant density model is adopted on the path of ants, that is, the amount of information released by forward ants in the path (j,i) is O.

(5) Global updating strategy of pheromone of backward ant

After the current ant arrives at the destination node, the collected path information from the source node to the destination node is recorded and transferred to the backward ant through the "Hello" message, and it will be deleted. In the process of traveling along the direction path of the forward ant, the reverse ant updates the pheromone of the population globally. The update rules are as follows:

$$\alpha_{ji}^{h}(t+m) = W_{ji}^{R}(h)\phi\alpha_{ji}^{h}(t) + \frac{O(1\text{-}\phi)}{S^{O}} \tag{10}$$

Where $\alpha_{ji}^{h}(t)$ is the network energy consumption value of ant h in population S^{O} after one cycle.

(6) Setting the maximum and minimum values of pheromones

In telemedicine information query, in order to avoid the situation that the algorithm falls into the local optimal solution due to the high or low pheromone concentration of the path, the number of possible residual pheromones on each optimization path is limited to $\left[\alpha_{\min}, \alpha_{\max}\right]$, $\alpha_{\min}$ and $\alpha_{\max}$ are the minimum and maximum pheromones in turn. At the end of each cycle, the ant of the shortest path to be reserved is modified to $\alpha_{ji}^{h}(t)$, and the modification strategy is determined and selected according to the following equation after pheromone update.

$$\alpha_{ji}^{h}(t+m)=\begin{cases}\alpha_{\min}, & \alpha_{ji}^{h}(t)\leq\alpha_{\min}\\ \alpha_{ji}^{h}(t), & \alpha_{\max}<\alpha_{ji}^{h}(t)<\alpha_{\max}\\ \alpha_{\max} & \alpha_{ji}^{h}(t)\geq\alpha_{\max}\end{cases} \tag{11}$$

Where, $\alpha_{ji}^{h}(t+m)$ is the result of pheromone local update after the forward ant in the population transfers to the next node according to the pheromone of the population at time t+m.

(7) When the number of iterations of the ant population reaches the second batch of paths, the optimization algorithm can return to the remote medical sensor network. When the number of iterations of the ant population reaches the end of the second batch of paths, the optimization algorithm can return to the remote medical sensor network.

3. Results

System test is a test conducted for the complete system. The purpose of system testing is to test the system comprehensively to ensure that the system meets the design requirements. This section describes the performance test of the system in this paper, and demonstrates the feasibility of the system design in this paper. The system test mainly includes the following stages: test plan and design, construction of executable system, implementation test stage, change test in development, confirmation test after the system goes online, and summary stage. System testing is different from unit testing and integration testing. It emphasizes the comprehensiveness of testing and requires as perfect coverage testing as possible on the premise that conditions permit. Therefore, when designing test cases, we need to consider from different angles, including designing test cases from multiple angles and the comprehensiveness of a single test case. Because the telemedicine information query system has a large scale and many modules, this paper only tests and demonstrates the telemedicine information query as the main content.

3.1 Experimental data

The experimental data come from the telemedicine information of the city's top three hospitals. The types of telemedicine information mainly include: operation teaching, remote consultation, remote access, telemedicine, remote visit, remote access, remote monitoring, remote conference, etc. the amount of information is relatively large. The collected telemedicine information is denoised, and the total amount of telemedicine information that can be used as sample data is 5GB.

3.2 Experimental scheme

In order to reduce the experimental error and improve the reliability of the experimental results, the experimental scheme is set before the experiment: the performance of the system is verified with the index of system query results, scheduling cycle, energy consumption and throughput. Taking the system retrieval response time as the experimental comparison index, this system is compared with reference [12] and reference [13] systems.

3.3 Analysis of experimental results

3.3.1 System query results

Figure 7 is the result of feedback from the system when querying COVID-19 medical information.

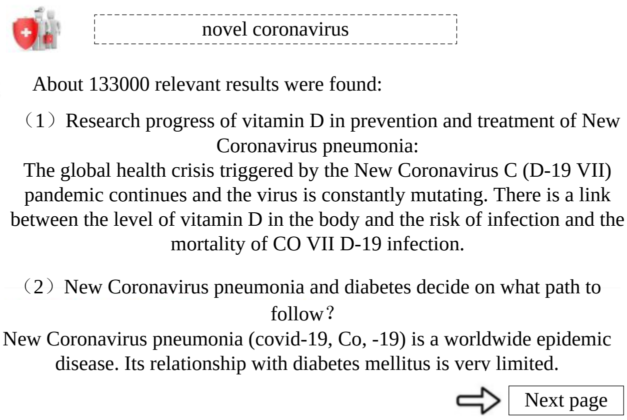

Figure 7. Query results of this system

According to the analysis of Figure 7, the system in this paper can complete the telemedicine information query according to the user query keywords, the query results cover a wide range, and the query function has passed the test.

3.3.2 Verification of dispatching cycle and energy consumption

The changes of routing topology, path scheduling cycle and network energy consumption with weight coefficient in wireless sensor networks under different network sizes are investigated. The number of source nodes in the wireless sensor network is 10 and 40 respectively. The comparison of scheduling cycle and energy consumption under different weight coefficients is investigated. The simulation results are shown in Figure 8 and Figure 9 respectively:

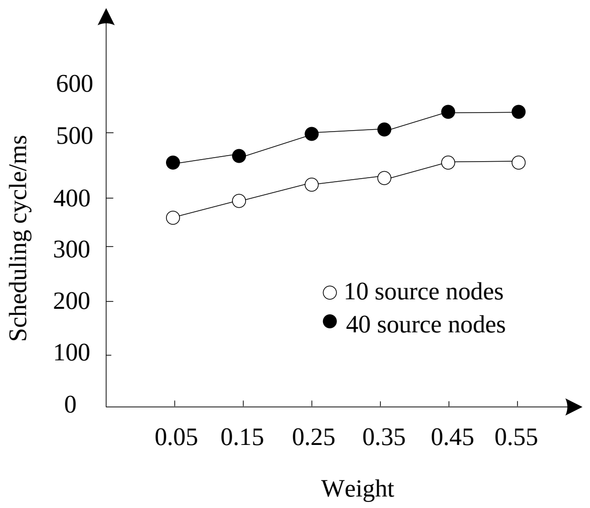

Figure 8. Comparison of scheduling cycles under different energy consumption weight coefficients

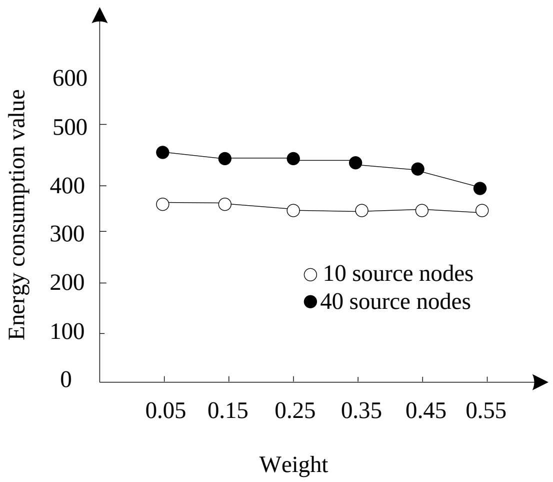

Figure 9 Comparison of energy consumption under different energy consumption weight coefficients

As can be seen from Figures 8 and 9, with the increase of the number of source nodes, the corresponding scheduling cycle increases. At the same time, it can be found that the larger the proportion of the weighting factor is, the smaller the corresponding energy consumption value and the longer the scheduling cycle are. Therefore, when setting the weight, it is necessary to analyze and set it reasonably, and it is best to set it at 0.25 ~ 0.35.

3.3.3 System throughput

When applying telemedicine information query system, due to the huge amount of medical information, the throughput calculation method of information query is as follows:

$$TPS = \frac{\delta \times \gamma}{n \times T} \tag{12}$$

In the formula, TPS represents the throughput, δ represents the total number of packets obtained by each node, γ represents the size of packets, n represents the number of nodes, and T represents the simulation time.

When setting the system application in this paper, the sending queue length of sink node in wireless sensor network is 4, the initial energy of sink node is 0, the energy required by node to transmit a single packet is $\frac{4}{10^5}$, the energy required by node to transmit a single packet is $\frac{2}{10^{10}}$, and the data aggregation energy required by node to transmit a single packet is $\frac{6}{10^{10}}$. The communication distance between each node is 15, and the number of simulation runs is 4000. In this paper, the system throughput and the residual energy of Sink nodes change before and after using the routing optimization method of wireless sensor networks based on improved ant colony algorithm are shown in Figure 10 and Figure 11.

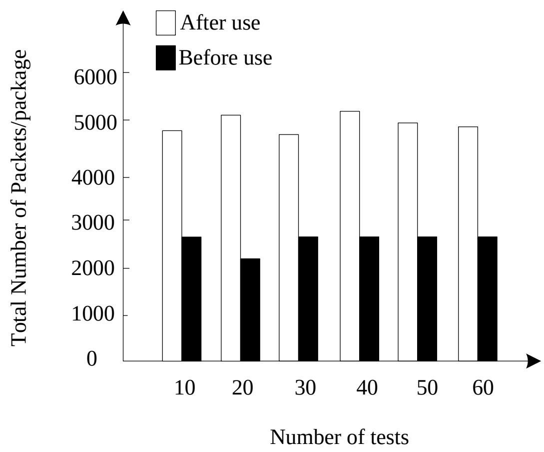

Figure 10. Throughput test results

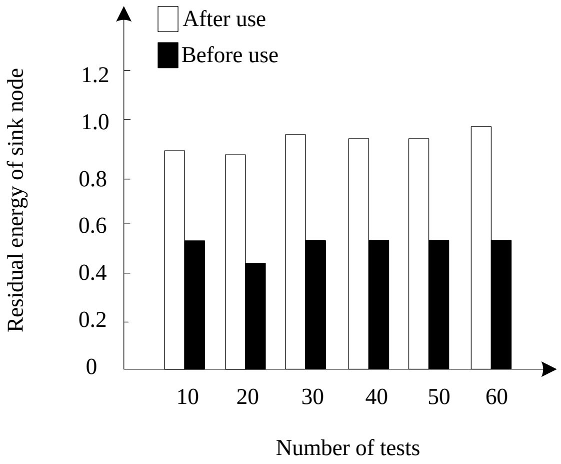

Figure 11. Comparison of residual energy of sink node

By analyzing Figure 10 and Figure 11, it can be seen that the throughput of the system in this paper is significantly different from the residual energy of Sink node before and after using the routing optimization method of wireless sensor network based on the improved ant colony algorithm. After using this algorithm, the throughput is greater than 1000, while the residual energy of sink node is significantly larger, indicating that the use of this algorithm can improve the throughput of the system in this paper and the residual energy of Sink node, and prolong the network life cycle, so that the effect of wireless sensor networks on medical information transmission is optimized.

3.3.4 Comparison and verification of system response time

In order to further verify the performance of the system, taking the response time of system retrieval as the experimental comparison index, this system is compared with reference [12] and reference [13] systems. The shorter the system response time is, the stronger the performance is. The comparison results of system response time are shown in Table 1.

Table 1 Comparison results of system response time

Number of tests	Response time/s		
	This article system	Reference [12] system	Reference [13] system
10	0.35	1.89	2.13
20	0.37	2.01	2.07
30	0.34	1.96	1.96
40	0.41	1.98	1.99
50	0.43	2.05	2.14
60	0.42	2.11	2.36

From the comparison results of system response time shown in Table 1, it can be seen that the longest response time of the system in this paper is not more than 0.5s, while the longest response time of the two comparison systems is more than 2s. Therefore, it can be seen from the above results that the system in this paper can effectively shorten the response time and improve the application performance of the system.

4. Discussion

Combined with the research content of this paper, aiming at the development trend of telemedicine information query system, this paper discusses its existing problems and gives relevant suggestions.

4.1. User factors

4.1.1 Existing problems

The acceptance of users is very important for the dissemination of telemedicine information query system. According to the data, China's telemedicine information query system faces four user related problems:

(1) The cost of telemedicine information inquiry system exceeds the average income level and the family's ability to pay. Therefore, the market of telemedicine information query system is very small, especially in rural areas.

(2) Telemedicine information query system conflicts with Chinese medical culture. Chinese traditional medicine pays attention to the communication between doctors and patients, but the telemedicine information query system is a long-distance communication.

(3) Hospitals lack it personnel who can operate and maintain telemedicine information query system.

4.1.2 Countermeasures

(1) The government can formulate corresponding preferential policies for the rural population so that they can enjoy cheap telemedicine services. Telemedicine services in rural areas should focus on the mode of low cost, storage and re transmission.

(2) It should increase the publicity of clinical research and show the effect and high cost performance of telemedicine information query system.

(3) Hospitals should establish appropriate incentive mechanisms to promote the implementation of telemedicine. Finally, it should strengthen the training of employees, train and equip personnel who understand both basic medical knowledge and computer multimedia knowledge and operation technology, so as to ensure the smooth implementation of telemedicine. It manufacturers should also invite doctors to participate in the system design process, so as to ensure that the system is easy for doctors to use.

4.2. System factors

4.2.1 Existing problems

(1) Most rural areas do not have adequate telecommunications infrastructure.

(2) The construction of telemedicine information query system lacks unified medical norms and technical standards. Various hospitals repeatedly develop software, and the system is not compatible, which makes the medical information can not be effectively shared. It is difficult to realize the open interactive networking of national telemedicine units. At present, the widely adopted health data standards in the world mainly include HL7 (American health information transmission standard), DICOM and SNOMED (standard medical reference term), but these standards are English platforms and cannot be directly applied to Chinese telemedicine information query system.

4.2.2 Countermeasures

(1) The central government should give priority to the development of technological infrastructure in rural areas. Local governments and academic institutions in rural areas should also strive for donations to help develop their telemedicine infrastructure.

(2) A set of national standards compatible with international standards is needed. The Ministry of Health has organized medical schools and academic institutions to develop the above standards. These standard construction projects must be accelerated. In particular, when developing these standards, we should pay attention to the characteristics of Chinese and China's health care system.

5. Conclusion

In order to improve the throughput of information query system and shorten the response time, a telemedicine information query system based on wireless sensor network is designed, and the performance of the system is verified from both theoretical and experimental aspects. The system has high throughput and short response time, and the maximum response time is no more than 0.5s. Therefore, it shows that the designed system has strong practical application performance and high application value. At the same time, there are still some problems worthy of research and improvement in this paper. In the future, targeted research can be carried out on the system security and the service capability of the system, so as to protect the private information in the system and provide a platform for patients to communicate with each other [23].

Fund project

The paper was funded by Science and Technology project in Henan Province with No.212102210100.

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