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On home health monitoring and telecare system: A new solution for medical service

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ABSTRACT

In aged society and modern life, chronic diseases and sub-health have become more and more common. It is very urgent and challengeable to provide medical services for people who have suffered from these diseases. Compared with traditional medical service pattern, in which patient must go to the hospital to see a doctor face to face, telemedicine and telecare can satisfy both the patient and doctor in a remote environment. Based on the concept of telemedicine and telecare, this paper proposed a new solution for medical service, in which patients can monitor their own health conditions and share medical services at home, health practitioners can provide professional medical services for patients at remote locations, and medical organizations can analyze the regional distribution of diseases in their offices. According to these results of requirement analysis, the Browse/ Server system architecture is adopted and the corresponding thematic function modules are designed. With the integrated application of information technology such as sensor, communication, network, database and geographical information system, the proposed home health monitoring and telecare system, which seamlessly links the patients, doctors and medical service institutions together anytime and anywhere, is developed. The case applications show that this system is feasible in technique and effective in practice.

KEYWORDS

Health monitoring;
Telecare;
Medical service;
At home;
GIS.

INTRODUCTION

With the improvement of living standard, people pay more attentions to their health. However, the increase of sub-health and chronic diseases are always attack people's health, especially in the modem life with fast pace and in the aging population society. People living with more than one chronic condition face particular challenges, both medical and social, and the quality of care services that these patients receive should clearly be improved[1].

At present, most health monitoring and care service are still a face to face way, which needs to be registered, queued in the hospital and cannot prevent disease or even cannot control the health condition at an early stage. So new organizational models and technical systems should be provided to restrict health care expenditure and offer appropriate and timely care[2]. A

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lot of researchers around the world try to propose the concept of telemedicine and telecare to solve this problem. Obviously, it is the applications of telecommunication and information technologies in medical field, which share and maintain patients' health information so as to provide them with services of clinical care and health education for medical professionals in a remote and separate environment[3]. However, most of these researches still stay at the conceptual level so far. A complete system hasn't been formed perfectly.

As the development of information technology such as wireless communication, wearable sensors, database system and Geographic Information System (GIS), advanced multi-parametric health monitoring may be achieved[4-7]. It makes a new breakthrough in telemedicine. Based on the new technology, a home health monitoring and telecare system (HHMTS) has been proposed in this paper. It provides an interactive and cost-effective medical service for patients in their own, natural environment. Therefore, without going to hospital, patients can know their heath condition well and get appropriate and professional medical care service at any time, day or night.

REQUIREMENT ANALYSIS OF HHMTS

HHMTS is an integration of medical, communication and information technology. It aims to fulfill the digitalization of entire process in home health monitoring and telecare, which covers the data detection, acquisition, transmission, storage, management, analysis, application and service of patient's main physical and mental health. Firstly, it should be able to acquire and transmit the medical data, and accomplish the data storage and archiving. Secondly, it should realize the data modeling and automatic diagnosis of common diseases. Thirdly, it could provide data management, analysis and service in the central station.

DESIGN OF HHMTS

System architecture design

The potential end users of HHMTS mainly include patient, central station, health care worker and public health service institution. By using Browser/Server (B/S) schema, the system combined all these objects together organically. As shown in Figure 1, this system adopts a three-tier architecture, including data acquisition layer, data management layer and application layer. The bottom tier is the fundamental layer, which is used for data acquisition and transmission. Medical, non-medical data and spatial data are sent through the network (wired or wireless) to the central station which services as a database server. The data management tier is located in the central station. It includes a computer-based multi-channel data analysis and display unit that enables the interpretation, display, and storage of the received data. In the application tier, a lot of medical services are provided for different users like physician, patients and public health service institution who are at a remote location.

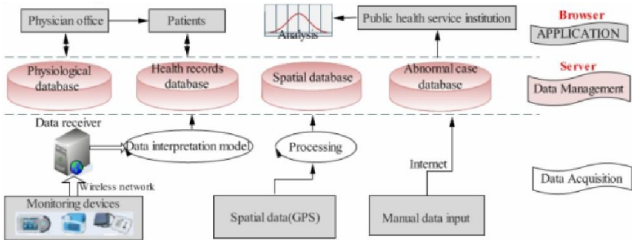

Figure 1 : System architecture of HHMTS

Design of the main function modules

Based on the designed system architecture and system requirements, the basic functional modules can be summarized as follows (Figure 2).

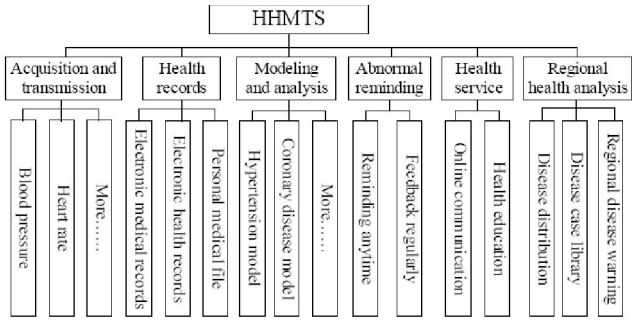

Figure 2 : Functional structure of HHMTS

(1) Data acquisition and transmission module. Patient collect physiological data by means of portable monitoring devices such as wearable sphygmomanometer and palm type oximeter at home. These devices carry intelligent sensors and Global Positioning System (GPS), which can send data to the database server through the internet, GPRS or wifi.

It supports both automatic and manual data access mode. Transmission between the patient and health worker should be bidirectional.

(2) Personal health records module. As an important part of the database, electronic personal health records offer the history data to health care worker and patient. They can be used not only to analyze patient's health trend, but also to provide reference for the medication and treatment options.

(3) Data modeling and analysis module. With the assistances of physiological data analysis model (Class libraries in the programmer), raw medical data could be identified by the online doctors. Business Intelligence (BI) and association rules are also used to analyze the chaotic monitoring data so as to extract valuable information about health care and treatment.

(4) Abnormal reminding module. By setting up special medical rules and models, this system is able to give diagnostic results automatically. Patients can receive abnormal reminding through text message, e-mail or web message. Like an online private doctor, the automatic reminding module provides health care knowledge and further treatment information for patients.

(5) Health service and counseling module. In addition to the automatic diagnosis and alert mode, health care worker needs to do further diagnosis for patient. And some general consulting services such as online exchange, health education and health reports should be provided.

(6) Regional health analysis module. It should be able to generate regional disease distribution map according to the corresponding disease case library and patients location information based on GIS and GPS.

DEVELOPMENT AND APPLICATION OF HHMTS

Development environment of the system.

Visual C#.net and ArcEngine have been chosen to be the programming language and GIS component respectively to development the system. SQL Server is used as the database management system to provide data service. Since the system adopts B/S schema, the end users don't have to install any other extra program except a computer with an internet browser.

Data acquisition, transmission and storage

In the B/S schema, server is located at the central station, in which several medical databases are included. Through the preset accounts, passwords and protocol, different users can realize the data exchange with the server. The users of the system can be patient, health care worker and public health service institution. For an example, the system allows a patient to collect his health data automatically or manually. As shown in Figure 3, these data can be measured by monitoring devices and then transmitted to the central station by GPRS, wifi or other wireless communication ways. Additionally, patient can also submit these data online manually. All the data would be stored in the database server at the central station.

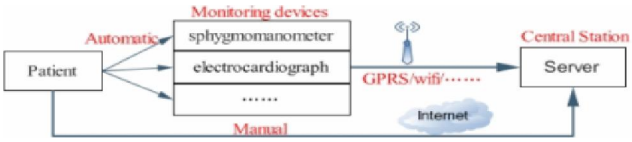

Figure 3 : Acquisition, transmission and storage of patient's health data

Modeling, analysis and application

Application in ECG data

As one of the most common chronic diseases, heart disease has a high incidence. Patients with heart disease need to get special care services. HHMTS is just able to provide a twenty-four hours supervision for them. As shown in Figure 4, it has four key steps: (1) patient gets own electrocardiogram data and transmits them to the central station; (2) the data are interpreted and automatically analyzed through the data model to find out whether it is normal or not; (3) data are stored in abnormal case database and physiology database in the server; (4) patients, health practitioners and public health service institutions can use the data through the browser. Patient will get reminded or alarmed if something is abnormal in his/her electrocardiogram, communicate with his/her health practitioners online and query his/her historical medical data (Figure 5).

Application in systolic pressure data

Hypertension is another common chronic disease,

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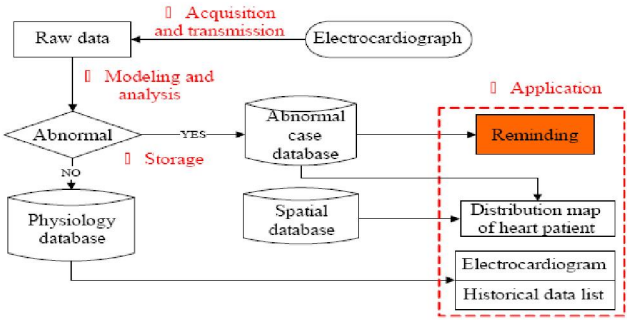

Figure 4 : Flow chart of electrocardiogram data processing

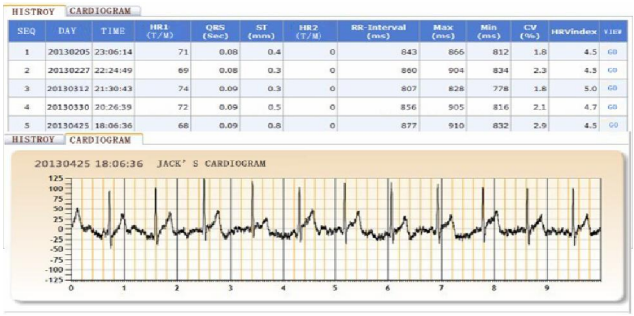

Figure 5 : History electrocardiogram data after parsing

which is easily affected by the environment[8]. Health care worker need to track patient's blood pressure periodically so as to provide diagnosis and treatment suggestions for patients. As the standard of the normal value is different from patient to patient, after receiving the data, the system first judge whether the patient has a personal standard. Then it compares the measured data with international or personal standard to find out whether the data is normal. No matter the data is normal or not, it would be stored in the database which is located in the central server (Figure 6). Patient can view the result and cartogram (Figure 7) by accessing the database online. The cartogram is very helpful for patient to know the dynamic changes of the health status. Moreover, patient would receive warning message when his/her blood pressure is abnormal.

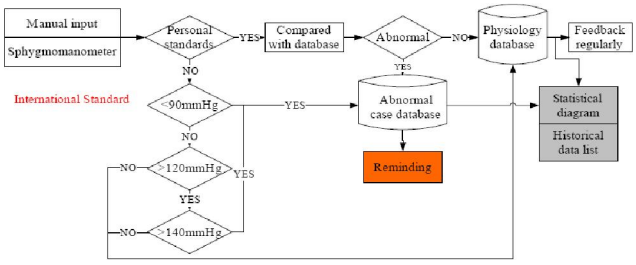

Figure 6 : Flow chart of systolic pressure data processing

Application in regional health condition

The monitoring devices carrying GPS module can get their position information. As the physiological data are transmitted to the central station, the position information is also sent and stored in the database. The system associates the position table with the abnormal table, and then generates distribution layer of patients by utilizing GIS. Public health service institution and other related interesting users can draw thematic disease distribution map by age, region and other features based on spatial overlay analysis in GIS. In the map, different rendering color represents different severity. Histograms can also be used to express the distribution of different parameters such as age and sex. Figure 8 is an example of the distribution map of coronary heart disease with ages.

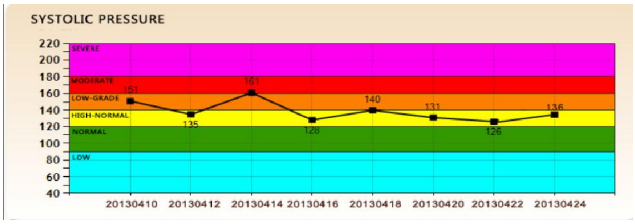

Figure 7 : Dynamic change and status diagnosis of systolic pressure

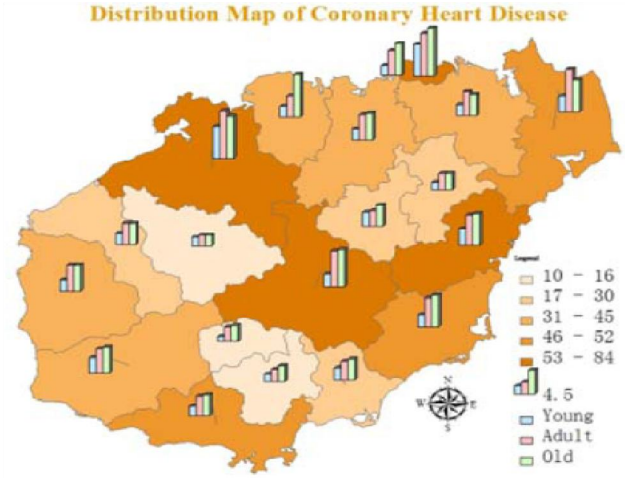

Figure 8 : An example of thematic distribution map of regional health

CONCLUSION

This paper proposes a new, integrative, highly sophisticated and cost-effective home health monitoring and telecare system. It can seamlessly connect patients situated at home with central station managed by health practitioners. The vital health signs to be monitored may include blood pressure, oximetry, temperature, heart

rate and so on. The results show that the diagnosis and management decisions provided by HHMTS are comparable to those made in hospital by face to face.

In this system, the health monitoring devices are quite important, especially for aged patients. With the development of internet of things, more and more wearable or potable measuring equipments will be available in the near future. Additionally, more professional diagnosis models should be provided to adapt the improvement of new devices. Besides the personal health monitoring and care service, future study can be focused on the relationship between environmental factors and diseases based on the regional health monitoring results.

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