Proceedings of the 2005 IEEE
Engineering in Medicine and Biology 27th Annual Conference
Shanghai, China, September 1-4, 2005

Remote Heart Sound Monitoring System

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***Abstract*: A kind of remote monitoring system on heart sound is constructed, which can tele-monitor ECG and PCG. The system integrates embedded internet technology and wireless technology. As it can send ECG and PCG by internet, it realizes real-time recording and monitoring of physiology parameter of patients at low cost and both at home and in hospital, and it also can be used for analysis for computer or reference for doctor. This study demonstrated that such kind of tele-monitoring system provides a low-cost, reliable and convenient solution for data acquisition and analysis of the PCG.**

I. Introduction

The remote medicine is a combination method that uses the technique of telecommunications, the technique of computer medium and the apparatus of clinic monitor to provide the medicinal information. It includes remote diagnoses, remote monitoring, remote education, and remote medicinal information services, etc.

The auscultation of the heart gives the clinician valuable information about the functional integrity of the heart. With the development technique, mechanical and electrical events of the cardiac cycle make more information of the heart become available. Thus the phonocardiogram comes into being, which is a recording of heart sound murmurs as a function of time. Clinical studies in humans have demonstrated that spectral analysis of heart sounds and murmurs extracted from the PCG provides important information on the heart valve structural integrity and hemodynamic performance [4-5]. However, the traditional way of making diagnosis for heart diseases is mainly auscultation, which is inconvenient and need experienced doctor. In this paper, a special tele-monitoring system on PCG and ECG is constructed, which can make a live monitoring on PCG and ECG, review the previous recordings and can be used to analyze the individual heart sound and murmur for the detection of heart valve diseases.

II. METHODOLOGY

A. The Design of the Whole System

The remote monitoring system based on embedded Internet is shown in Figure 1. The key task of this system is to collect the cardio-electric and heart sound signals. The internet is used to transmit the parameters to monitor center, and then PCG displaying, recording and analysis are carried out in the monitoring center. Based on the Internet data traffic, this system takes the client server alternative model that is widely used in Internet communication [1-2].

The whole system is mainly composed of the client interface, Internet and the server in monitoring center. The client interface is the front interface in the monitoring system that connects with the patient directly, and it can do the following tasks: the collection of body's physiological data, and wireless transmission. Theoretically, there is no limitation on the numbers of the client in this system. So long as the internet bandwidth and the management capacity of the server can cope with, the number of the client can be expanded at will. The patient can stay at home, in the ward or even in his office. As long as there is an Internet interface, the system can work.

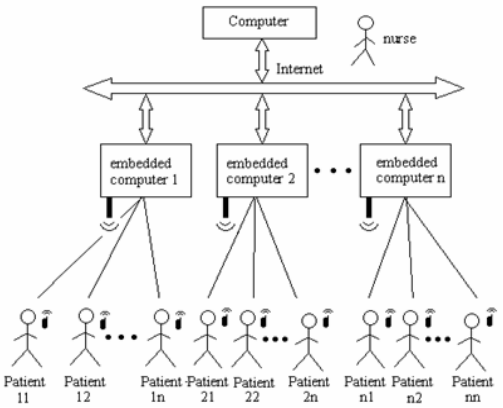

Fig.1.Remote monitor system structure

Depended on the number of the client, the server in the monitor center can choose whether to use a high capability PC, a workstation or a server. There should be enough bandwidth between the connection of the server and Internet to ensure that the data from all the patients can be sent to the server successfully. This design also adopts the short-distance wireless data transmission technique. With this technique, the patient can have some movements within a range about 200 meters with a portable wireless data collection module on body.

B. The Design of Data Collection Module

The task of this module is to collect two channels of physiological parameters from patients and send them out

through the wireless sending module [3]. The STR100 is used as wireless sending module, which is Micro-power and Work in high frequency with a transmission distance from 200~1000m. The chart of data collection module is shown as Fig.2.

Piezo transducer is used as heart sound sensor, which is an element that generates an electrical current based on the physical pressure the element is subjected to. The electrical charge generated is proportional to the change in mechanical stress. It has a broad response frequency. The bandwidth of the ECG channel is from 0.05 Hz to 100 Hz and the bandwidth of the PCG channel is from 1 Hz to 1000 Hz. The sampling frequency for the ECG channel is 400 Hz and for the PCG is 8000 Hz. All the data are packaged together and transmitted to wireless sending module via MCU.

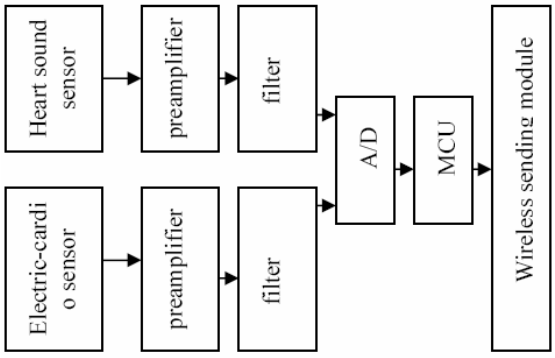

Fig.2. The chart of data collection module

C. The Choice of the Embedded Module

As for the way to get in touch with the Internet, there are ordinarily several methods such as MODEM dial-up, ISDN, ADSL, cable MODEM and Ethernet. In recent years, the broadband develops very fast, and almost every newly built house has the broadband line, and the connecting way is Ethernet. Whereas, this remote cardio-electric monitor system also take this method. On the other hand, because the Ethernet broadband system becomes more and more popular and the cost becomes lesser and lesser, it is reasonable to take this method. Also the speed to connect the Internet through Ethernet is faster than through the dial-up.

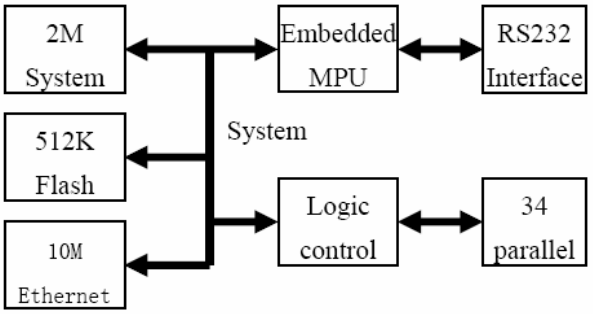

Fig.3. The module framework of ETR-232

The ETR232 network transition control module produced by ChengDo Yingchuang Company is used in the system. It has many performances such as 24/48MHzIntel386EX 32 bit MPU, 10Mbps Ethernet control interface, one standard RS232 serial port, BIOS compatible with PC/DOS, sustaining Borland C/C++ secondary exploiture and TCP/IP protocol warehouse corresponding to ETR232.

D. The Design of the Data Transmission Module

The core of the data transmission module is the ETR232 network transmission controlling module that has been introduced before. After the data of human body's parameter being received by a wireless module, the data is transmitted to the ETR232 module through a MCU. After the ETR232 module packs the protocol, it can be sent to the server in the monitoring center through Internet. The structure of the cardio-electric transmission data module can be seen in Fig.4.The data of human body's parameter accepted by the wireless module can be connected with RS232 serial interface of the standard ETR232 module via MCU and MAX232. After being processed in the ETR232 module, the data can be transmitted to Internet through the net interface. Meanwhile, people can use several parallel I/O interface of the ETR232 module to show the necessary state direction and give an alarm.

The power supply must be the 220V alternating current, so the circuit of the power supply adopts the linearity steady power supply circuit structure.

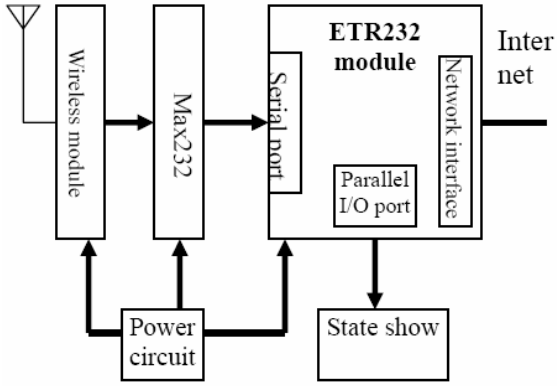

Fig.4. The structure of the cardio-electric transmission data machine

E. The Realization of the Network Communication

The task of this communication program is to transmit the cardio-electric and heart sound data to the server in the monitor center through Internet. The program is based on the client/sever alternative model, and is written in BORLAND C3.1 langrage. It comes true through the flexible use of the protocol storeroom function provided by the ETR232 module. The ETR232 module provided a storeroom function, which can be used in the Internet communication, and the application of the Internet communication is based on the transfer of this storeroom function. The protocol is TCP protocol that is based on link.

The program can be downloaded by Turbo Debugger function after compiling、compiling and linking as the Turbo Debugger has automatic function in downloading application to ETR-232. For example, C:\Myapp>td –rp1

NET-232. Turbo Debugger has a powerful program debug, which can detect error and exit debugging, and make modification till the accomplishment. The accomplishment announces the finish of program development, and then the system can run independently after the ETR-232 being set to running mode. The on-line data communication is based on the alternative model of client/server, and the computer in the monitor center is used as the server that is under the monitoring state at any time. Once a client send out the request to connect with the server, the server make connection with the client and use it to make corresponding disposal.

F. The Software on the Server

The software was programmed by LabVIEW, which is a graphical programming language for data acquisition and instrument control. It includes a well-defined set of comprehensive user-interfaces for building an instrument control panel. In the main interface, two charts were designed to display the PCG and ECG in real-time.

DataSocket, included with LabVIEW, is a new Internet programming technology that simplifies live data exchange among computers connected through a network .DataSocket is designed specifically for sharing, subscribing, and publishing live data in measurement and automation applications. In particular, datasocket is designed for live data transfer to multiple clients where a URL is used by users to connect to a data source location in the DataSocket server so as to control or share data with DataSocket applications. DataSocket simplifies network TCP/IP programming by automatically managing connections to clients and automatically converting measurement data, regardless of the types of data used or the source of the data, to and from the stream of bytes sent across the network [6].

The program run in the monitor center constitute of several functional modules, including network communications module, data analysis module, displaying module, data recording and playback module. Network communications module is under the monitoring state, making response to connection request and receiving data sent by client. Data analysis module makes a simple analysis, calculate parameter, verdict it and give alarm information. An analysis panel within which six cardio cycles of PCG and ECG signals are displayed is designed, and with the synchronization of ECG, a correlation algorithm was programmed to select a heart sound (S1 or S2) form any cardio cycle. Displaying module is to display the waveform of in computer and compute the spectrum and the time-frequency distribution. Data recording and playback module can deposit the received data in hard disk in file, which can be transferred for displaying or analysis in need. An example for ECG and PCG display is shown in Fig.5

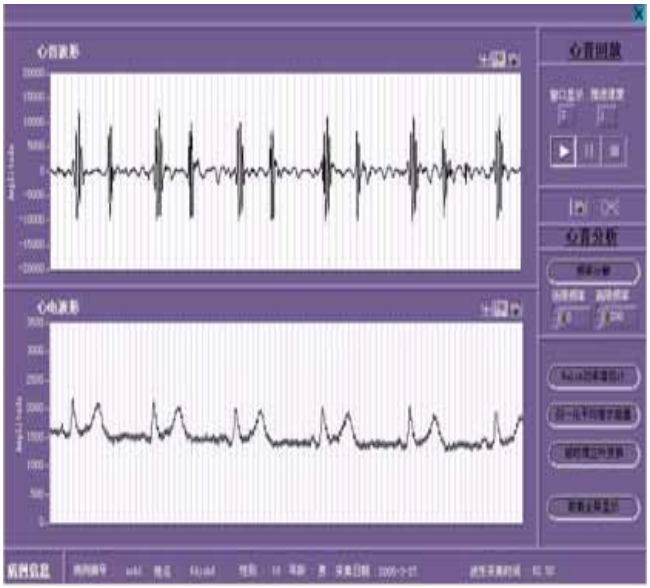

Fig.5.An example for ECG and PCG display

III. CONCLUSION

ECG and PCG can be tele-monitored at the same time, and through the ECG, The system can make an orientation of the first heart sound S1 and second heart sound S2 automatically. As Parameter can be transmitted in Internet, making it come into reality that body parameter can be monitored timely and remotely and have analysis function. This system will provide convenience both for the doctor and patient. This study demonstrated that such kind of tele-monitoring system provides a low-cost, reliable and convenient solution for data acquisition and analysis of the PCG.

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