Tele-Health ECG Monitoring System: A Low Cost Approach

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Telemedicine, ECG, ECG Recorder, TCP/IP, Internet.

Abstract
This paper describes an implementation of a low cost real time remote ECG monitoring system. The system is capable of acquiring and storing patient's ECG data and transfers it in real time to the remote terminal. It comprises of an acquisition and a networking part. The acquisition part acquires ECG signal through electrodes and then amplifies the weak ECG signal by an amplifier and filter out noises. ADC modules carry out A/D conversion of the ECG signal and fed into the interface circuit for level conversion. Serial port program enables data to be stored in a PC from acquisition device. The networking part is in the form of a Java based client/server pair application and installed in local and remote terminal respectively via TCP/IP to provide transfer of data and enable chat session. This system is utilizing Internet protocols, commercial software and low cost component to transmit ECG data to physicians for monitoring, diagnosis and patients care at a significantly low cost, regardless of patient's location.

Introduction
The use of electronic and communications technologies to provide and support health care when distance separates the participants is well known definition of telemedicine which was published in 1996 by the Institute of medicine [1]. Reports indicating that telemedicine has been a great concern for physicians with a passion for technology, and barriers still remain for a low cost, comprehensive and integrated use in the daily operations [2]. Telemedicine reduce costs by enabling in-home monitoring of patients, eliminating the need for utilization of expensive facilities, and reducing the need for transportation of patients to physicians and medical centers [3].

One application of telemedicine is to rapid transmission of electrocardiogram (ECG) data to physicians so as to improve patient care and conserve healthcare resources in managed care environment. ECG transmission has been particularly useful for pacemaker follow-up [4] and other patient monitoring applications [5]. The use of ECG transmission for emergency settings has been emphasized in order to reduce response time in infarct size control or resuscitation of sudden cardiac-death victims [5].

Real-time ECG transmission via the Internet has been previously reported elsewhere [6], in order to provide direct access to physicians in remote locations to coronary-care-unit patient-

monitoring data and to check patients being monitored at their homes. This paper describes a complete low cost real-time ECG monitoring system, including the signal acquisition hardware, client, and server applications, the required transmission protocols, and the consultancy features. The system is user friendly and does not require any particular training aside from knowledge of widespread and standard Internet tools. Due to the interactive approach of the proposed system, the physician is also able to make online consultation directly from the server software provided.

Design Overview

This project comprises of two main parts - namely ECG acquisition system and networking application. Electrodes are placed on human body to capture small electrical voltage produced by contracting muscle due to each heartbeat. The ECG signal obtained by the electrodes is in the range of 1 to 5mV. Due to the weak voltage level, the signal is fed into an instrumentation amplifier to amplify and filter the acquired signal. The amplified signal is then fed into the ADC circuit for A/D conversion. Digital output of the ADC is sent to local terminal (patient's terminal) via an RS232 interface circuit for level conversion. The digital data is then read and stored by a serial port program running in the local terminal and transferred to a remote terminal via TCP/IP and sets up a full duplex communication. There are various features such as plot graph, chat, play of sound clip and patient's database incorporated into the networking as depicted in Fig. 1.

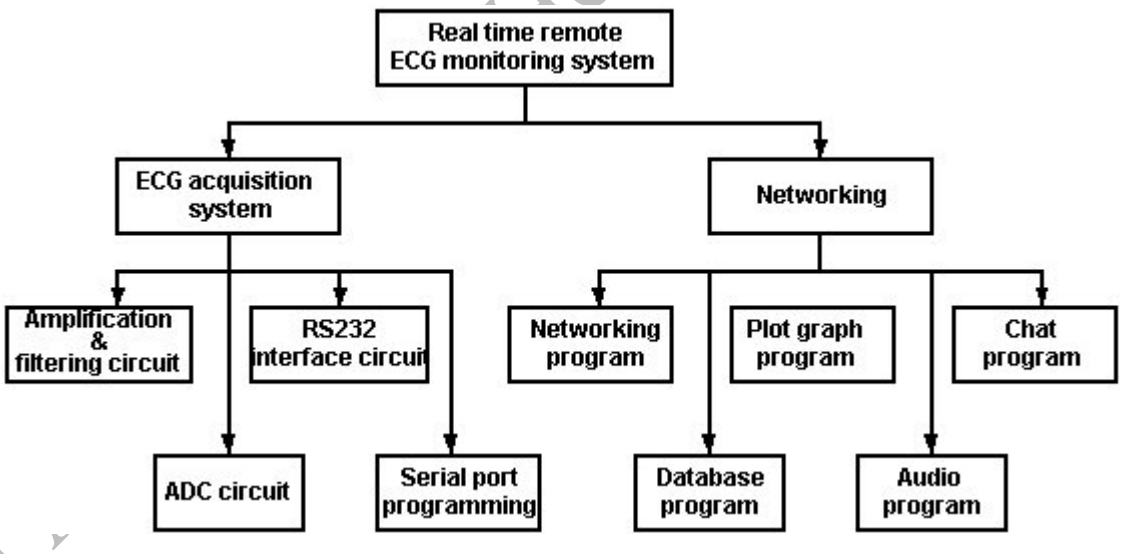

Figure 1: Structure of the project

Hardware Design

The first stage of hardware design for ECG data acquisition system is a simple ECG sensing, using electrode. The output from ECG sensor is fed into the second stage for signal amplification and filtering purposes. Next, the analog output from the second stage

is fed into the third stage for analog to digital conversion. Finally, the digital output from ADC is sent to a PC via an RS232 interface circuit. Fig. 2 shows the schematic diagram of the circuit.

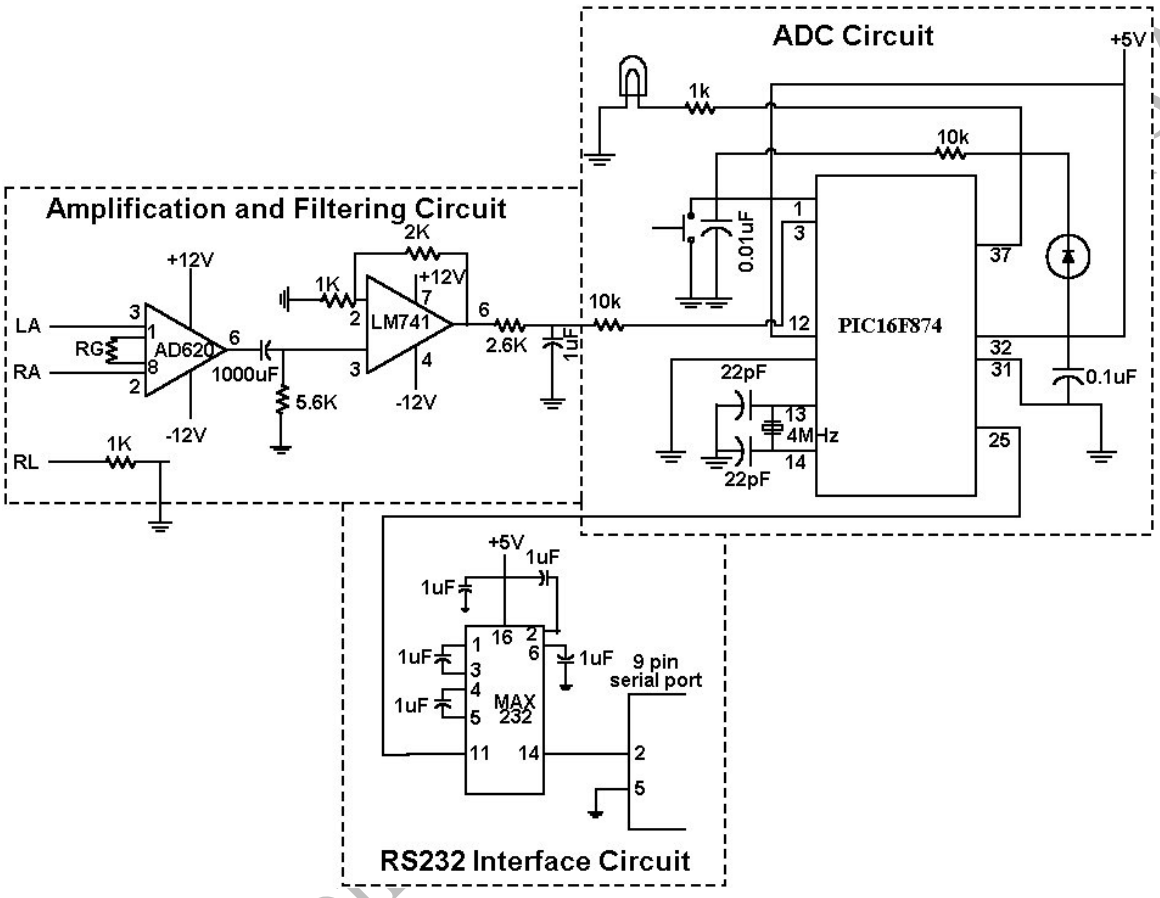

Figure 2: Schematic diagram of amplification and filtering stage.

Software Development

The software is developed using Java programming language and the networking program is manifested in the form of a client/server pair application. The client application, known as a Local Patient Monitoring System (LPMS), is installed in the patient's terminal (PC) while the server application, known as Remote Patient Monitoring System (RPMS), is installed in the physician's terminal. A connection is established when a user in LPMS chooses a desired location to be connected. The desired locations are restricted to the predefined hospitals or clinics. Once the network has been successfully set up, user sends ECG data file as well as sound file to RPMS. Physicians at the remote location display the ECG graph and carry out analysis on the patient's heart condition. The physician may also listen to the heart beat sounds using a standalone audio player, which enables the sound clip to be played and looped, as desired. In addition,

users from both ends can communicate with each other via a simple chat program that is incorporated in both LPMS and RPMS. Finally, RPMS has a patient's medical information database that enables patient's data entry to be created, updated and retrieved. The interface for both LPMS and RPMS provides similar features except for the database feature, which is only available at RPMS.

Networking module, Send audio file module, Chat module, Plot ECG-waveform module, and Audio player module make up the network program. The process of algorithm design and code writing is based on a modular architecture. Each of these modules is constructed separately using Java software JDK1.2.2. This programs are then incorporated into the Graphical User Interface (GUI) using Java IDE tool JBUILDER which coordinate and manage all these functional modules together.

Results and Discussion

A test is carried out on each part of the developed hardware to view how one affects the other. The AD620 has the common mode noise rejection ratio feature. Therefore, the 50Hz or 60 Hz line interface is reduced. However, there is still noise overridden on the ECG waveform. These noises are due to the electrical activity of the active muscle and white noise.

The low noise frequency that exists while measuring the ECG signal from human's body is greatly reduced through the low frequency filtering. It is noticed that the peak R-wave is clearly shown.

To test the networking program, both LPMS and RPMS is installed in respective computer and successfully execute all the modules.

Conclusions

The ECG data acquisition device is successfully developed. The device can get ECG data from human body and send the ECG data in digital form to a PC or patient's terminal. In addition, the network application successfully sets up a full duplex and point-to-point connection. The networking system enables transfer of ECG and heart beat sound files, online chat, ECG display and also retrieve, update and create patient's medical record database. Thus, the objective for this project, which is real time implementation of Electrocardiogram (ECG) data transfer is achieved.

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