Wireless Telemonitoring of Wearable Device for Recording Biopotentials Using Embedded Terminal Platform

Subashree Soumya Kannan and N. Shivaani Varsha

Abstract--- *This paper proposes a wearable device for recording various biopotentials for analysis and transmission of analyzed signals from a portable terminal to remote servers. This facilitates the experts to provide guidance from the places they are currently available to where it is required immediately. Portable device is designed using CC2540 network processor supported by wireless sensors for recording ECG, EMG and EEG. The key advantages of this processor are low power requirement, built-in Bluetooth and cost effective. OMAP 3530 is an embedded processor used to design the portable terminal supported by USB based Bluetooth device and a display. This portable terminal is efficient, energy saving and is very useful for wireless monitoring applications. Noise cancellation of acquired signals is done before transmitting them to remote areas using morphological filtering. Clean signal that is obtained enable the medical experts to provide exact guidance. The filtered signals are stored in a database at local areas and then transmitted to remote areas through network support provided by Wi-Fi or 3G technology.*

Keywords--- *Wireless Telemonitoring, Biopotentials, OMAP 3530, CC2540*

I. INTRODUCTION

WITH the advancements in technology, there is also outbreak of many diseases. In order to find remedies for existing diseases and to control the evolution of new diseases, continuous monitoring of patients for a long period of time is required. Analyzing various biomedical signals like ECG (Electrocardiogram), EMG (Electromyography), and EEG (Electroencephalograph) will enable the medical experts to exactly identify the health problems. To monitor the patients for long time, a device has to be designed that can be embedded onto the patient's body for continuous recording of biomedical signals. It can enable thorough follow up of chronic patients; diagnosis and identification of symptoms of various diseases; elderly people monitoring; human behavior in a specific environment. The key issues in designing portable biomedical instrumentation are: (1) consumption of power, (2) sensor should be stable for long time, (3) comfortable to wear, and (4) provide wireless connectivity.

As signals are transmitted through wireless medium, the signals are bound to get corrupted with noise of diverse recourses and forms: motion artifact, power line interference and base-line drift caused by the respiration. Due to this it becomes difficult to identify the information that reflects the characteristics of physiological activity. Morphological filtering is used to remove noise and to calibrate the base-line drift in the signals. This filtering approach is fast, simple and real-time in processing, and it keeps the biomedical signals shape unchanged while removing the noise. Noiseless signals enable the medical experts to provide proper guidance.

Portable terminal enable the transmission of signals to remote areas. This terminal is not attached to the wearable device because its addition would increase the mass of the wearable and make it uncomfortable to wear for the patients. Also, this platform provides extensible digital interface to biomedical sensors, thorough power management unit, a user-friendly interface design and ingenious driver programs to support hardware operations. This platform is easy for extending to various sensor configurations for different user conditions, such that mobile, user-centric healthcare services, such as traditional monitoring, remote medical consultation, and chronic disease management could be easily constructed on it with low cost. During situations where doctors may not be available at the hospitals during the time of need, the reports should be sent to the far away areas where they are presently available. The patients can be given immediate treatment without the need for the arrival of the doctors.

The proposal given in this paper gives the basic idea of a low cost product which contains a wearable device at an affordable cost for monitoring of health along with a portable terminal for transmission to far away areas. This concept is mainly useful in rural areas where the doctors may not be available throughout the day.

II. SYSTEM OVERVIEW

A. *The Whole Application System*

The whole application system consists of following parts: (1) wearable device that contains sensors and network processor, (2) portable terminal platform in which unwanted signals are eliminated and results are displayed, and (3) remote servers.

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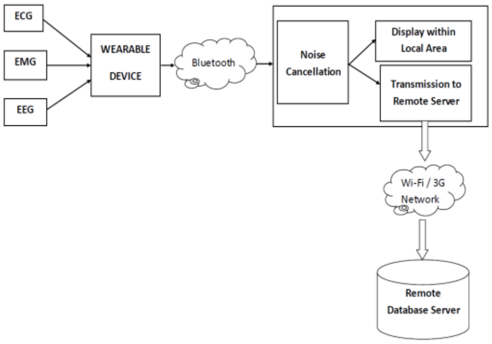

Fig.1: Simple Block Diagram of Proposed System

A. *Hardware Details*

Hardware to be implemented contains two major parts: wearable device and portable terminal.

Wearable device that is designed consists of sensors that record the signals such as ECG, EMG and EEG and a CC2540 network processor for storage and transmission. CC2540 is an 8-bit processor that contains the following merits: (1) software features include Bluetooth v4.0 compliant protocol stack; multiple configuration options like single chip configuration allowing application to run on cc2540 or network processor interface for applications running on an external microcontroller; (2) hardware features include short transition between operating modes enable low power consumption; low energy true system on chip (Soc); slave nodes can be built with low material costs; excellent RF transceiver; 8-KB RAM; in system programmable flash memory; (3) wide range of applications like mobile phone accessories; sports and leisure equipment; consumer electronics health care and medical; human interface devices like keyboard, mouse, remote control.

Portable terminal is made up of OMAP3530 (Open Multimedia Applications Platform) embedded processor which is used for the display as well as store the results of the patient in a database present at the local areas. The key features and benefits of 720 MHz OMAP3530 processor are: (1) sends 1400 Dhrystone million instructions per second (MIPS); (2) good quality audio and video; (3) supports 3D display and gaming effects; (4) high performance, low power operation and low power standby features; (5) a complete product portfolio based on a single platform can be created efficiently; and (6) has the ability to run full-featured operating system.

By providing proper network support though Wi-Fi or 3G technology, the reports can be transmitted to remote areas for expert's guidance. The range of Wi-Fi can be chosen based on the distance for which the signals have to be transferred.

B. *Software Details*

The coding is done using Embedded C Programming. The advantage of embedded C are: (1) a piece of software written can be implemented into hardware for performing various functions, (2) small, reasonable easier to learn, understand, program and debug, (3) C compilers are available for most of the embedded systems, (4) C compilers are processor independent and can run on most of the systems (5) it deals with microcontrollers, I/O ports.

C programming is required (1) to integrate the CC2540 processor with various external sensors and (2) for noise cancellation to be done at portable terminal as soon as the signal is received using morphological filtering.

III. SIMULATION RESULTS

The simulation results generated using MATLAB is presented below:

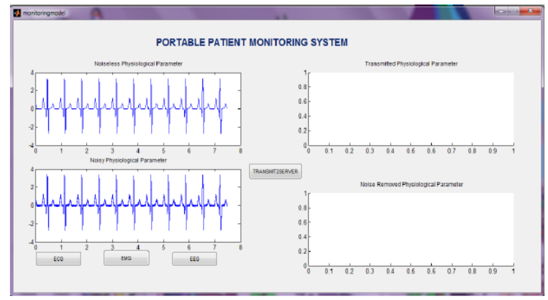

Fig.2: ECG Signal Acquisition

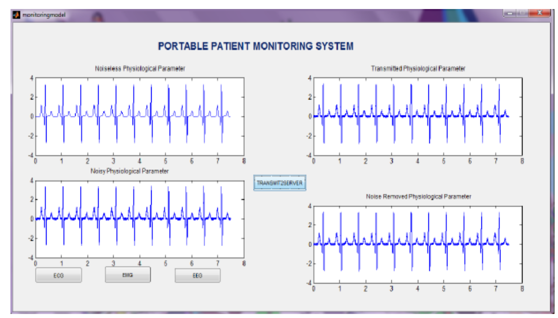

Fig.3: ECG Signal Transmission

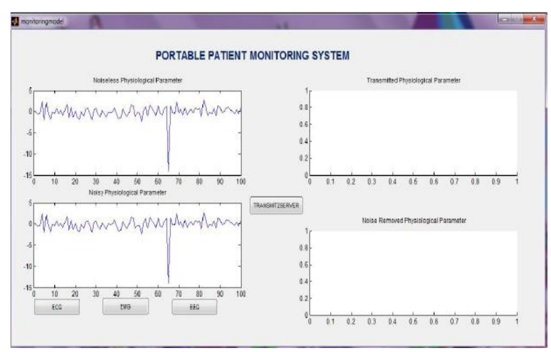

Fig.4: EEG Signal Acquisition

Fig.5: EEG Signal Transmission

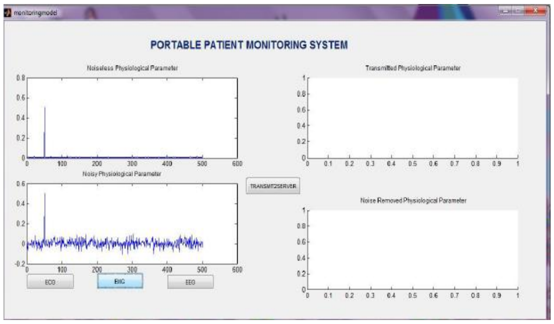

Fig.6: EMG Signal Acquisition

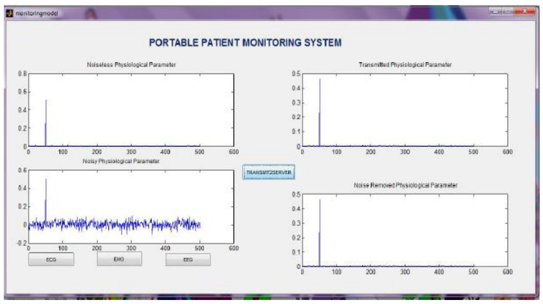

Fig.7: EMG Signal Transmission

Fig.8: Filtering for Low Intensity of Noise

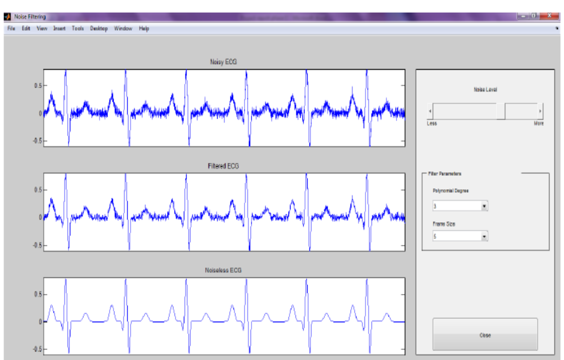

Fig.9: Filtering for High Intensity of Noise

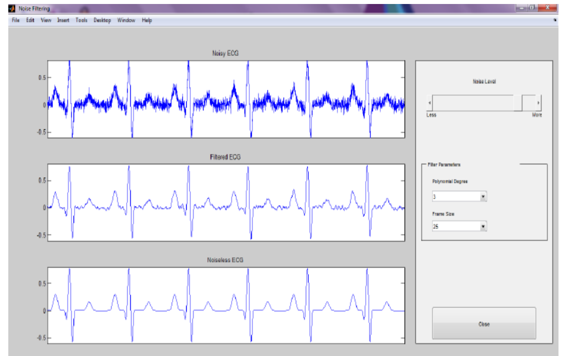

Fig.10: Filtering for Very High Intensity of noise

IV. IMPLEMENTATION OF HARDWARE

The entire hardware implementation can be divided into three parts: (1) wearable device, (2) portable terminal, and a (3) remote server.

Wearable device used by the patient has to be embedded onto the patient's body part from where the signal has to be taken. These sensors are interfaced with CC2540 network processor to collect signals continuously. This processor contains microprocessor and built-in Bluetooth for transmission to the portable terminal located at the local hospitals.

Portable terminal is designed using OMAP3530 that is supported by USB based Bluetooth device to receive the signals from the wearable device. An embedded C program is coded into this terminal for noise cancellation using morphological filtering. Once the noises are filtered, the final reports are displayed. Through Wi-Fi support provided in the terminal, the reports can be forwarded to the required designation.

The remote servers collect the signals and the doctors can analyze them immediately and give the necessary instructions.

V. CONCLUSION AND FUTURE WORK

In the existing system, there is no facility of providing network support to faraway places at low cost.

This paper proposes the embedded terminal platform for wireless telemonitoring of wearable device at affordable rate. The facility of noise cancellation is also added as an additional feature. The above project is a complete product that can be used for portable biomedical applications.

Compared to the existing system, the idea proposed in this paper mainly aims at providing affordability and avoids the necessity of travelling to the hospitals for conducting tests. In this paper, specifications are given taking into account the cost of the entire product.

As future work, different network processors can be used in wearable device and portable terminal. Also, morphological filtering can be combined with additive filtering to produce better denoised results.

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