Available online at www.sciencedirect.com

ScienceDirect

IERI Procedia 4 (2013) 208 – 215

Procedia IERI

www.elsevier.com/locate/procedia

2013 International Conference on Electronic Engineering and Computer Science

A Wireless Health Monitoring System based on Android Operating System

Dongdong Lou[a,b], Xianxiang Chen[a], Zhan Zhao[a], Yundong Xuan[a,b], Zhihong Xu[a,b], Huan Jin[a,b], Xingzu Guo [a,b], Zhen Fang[a,]*

[a]*Institute of Electronics, Chinese Academy of Sciences, BeiJing,100190,China*
[b]*University of Chinese Academy of Sciences, BeiJing,100049,China*

Abstract

This paper describes a mobile health monitoring system which consists of a portable multifunctional physiological parameters detecting 3AHcare node and a mobile program for real-time data telemetry based on the smartphone with the Android operating system. The 3AHcare node is a health monitoring device with embedding Bluetooth module in it and capable of measuring a subject's ECG, blood pressure, blood oxygenation, respiration, temperature and motion – almost equivalent to the feature set of a hospital bedside patient monitor. In the Android Application, we receive physiological parameters such as ECG via the socket connection between the Android device and the detecting module; we process the received data with special algorithms to get steady waves; we store data locally on microSD flash; we display data by waveform and digit; we alarm by threshold algorithm and we realize remote data transmission via TCP/IP protocol. We have evaluated the performance of the monitoring system in capturing, recording, transmitting and displaying ambulatory data and found the system easy to use and with high precision.

Selection and peer review under responsibility of Information Engineering Research Institute

Keywords: Mobile health system; Android; Bluetooth; physiological parameters

* Corresponding author. Tel.: +86-10-58887195; fax: +86-10-58887195.
E-mail address: zfang@mail.ie.ac.cn.

Selection and peer review under responsibility of Information Engineering Research Institute
doi:10.1016/j.ieri.2013.11.030

1. Introduction

In modern lives, health surveillance plays an increasingly important role in the daily life and there are more and more people with the problem of chronic disease[1], but the traditional health care mostly is confined to hospitals and other fixed place, which is not convenient for the user to move. In order to achieve the purpose of continuously monitoring the patients' physiological information such as electrocardiograph, body temperature and respiration rate for a long term, mobile health care is needed.

The development of the Body Sensor Network (BSN) technology makes it possible to continuously monitor physiological parameters such as electrocardiograph (ECG), respiratory rate, electroencephalograph (EEG),blood oxygenation (SpO2), body temperature, etc for a long time[2].

It mainly thanks to the following two aspects of the technology advances: Firstly, the advancement of precision micro power amplifiers, microcontrollers, and MEMs technologies have enabled the development of very small, low power, wireless health monitoring technologies. Our approach has been to develop a highly integrated ambulatory device which reduces cost and improves reliability by reducing the number of components and differs from most devices that only have one or two sensing modalities or require multiple networked devices attached to the subject. Secondly, with the development of mobile communication technology and microelectronics technology[3], smartphone already has the characteristics of large-capacity storage, high-speed and high-precision processing chip, large touch screen, GPS navigation, high-capacity battery, good man-machine interface and powerful communication function. Especially, with open operating system and the ability of installing and uninstalling new applications make smartphone more and more used in the health field, particularly mobile health fields[4]. Compared with the monitor based on PC or PDA, smartphone is smaller and easier to be carried, has a long-distance data communication capabilities and with diverse functions. In this paper, a mobile health monitoring system capable of monitoring a subject's physiological parameters is designed and implemented. The monitoring system is not only able to measure, analyze, store various physiological parameters of the patients' continuously and in real-time, but also can alarm automatically if the physiological parameters were beyond the normal values and transmit the physiological data to the remote server via TCP/IP protocol[5]. The most important is that existing monitoring systems similar with this are almost none.

There are two parts included in the monitoring system, the 3AHcare node is used as the hardware part and a APP is considered to be the software part. A 3AHcare node can realize continuous measurement of seven leads ECG, respiration, temperature, blood pressure, SpO2 in real time. The APP is used to get, store, process, transmit physiological data and alarm automatically. Because of high market share, low price and openness characteristics of Android, the APP is developed on Android operating system with Android SDK and NDK. Bluetooth wireless communication technology is used for the communication between the two parts.

2. The system components

The monitoring system is made up by physiological parameters acquisition module and Android smartphone application module. Physiological data is transmitted between the two parts via Bluetooth, and WI-FI or 3G network is also used to realize remote data transmission with the remote health server. We use 3AHcare node as parameters acquisition module. The 3AHcare node is able to continuously measure seven leads ECG, respiration, temperature, blood pressure and SpO2 in real time, and via wireless standard communications protocols of Zigbee and Bluetooth, it can be used for exchanging data with other devices.

After fully considering the characteristics of the existing smartphone operating systems, we decide to develop our monitoring application with the Android operating system which is open, interface friendly, and network function powerful. We use HUAWEI C8813 as a prototype to test our monitoring application, some

of the necessary parameters about C8813 are as follows:4.5-inch screen size, 854x480 pixel resolution, 1228MHz CPU frequency, Android OS 4.1 operating system, 512MB RAM, 4GB ROM , supported by Bluetooth 2.1+EDR,WLAN,WI-FI and GPS.

Complete system components are shown in Figure 1. Bluetooth and WiFi or 3G is respectively used to realize data transmission among 3AHcare node, Android smartphone and remote health server.

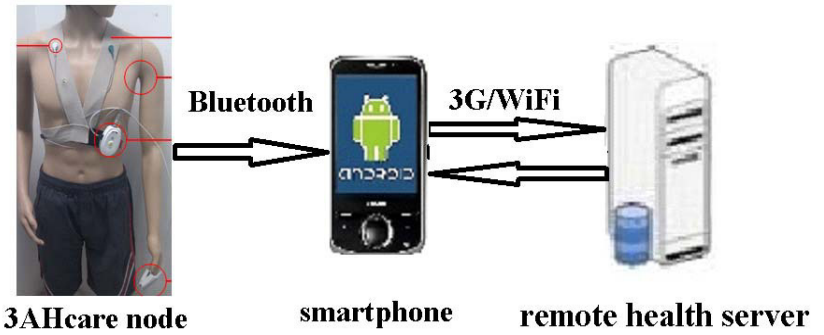

Fig.1.System components

3. The 3AHcare node

The IECAS 3AHcare node differs from most other wireless health monitoring devices in that it incorporates a large number of sensing modalities on a single small device [6]. This allows for a number of advantages such as requiring only a single circuit board, a single battery, and no need for inter-device communication simplifying the end user experience. It can realize continuous measurement of seven leads ECG, respiration, temperature, blood pressure, SpO2, the motion state of wearer in real time. It highly integrated four function modules: microcontroller module, several sensors and signal processing module, wireless communication module and power management module in a single board, as shown in Fig. 2.

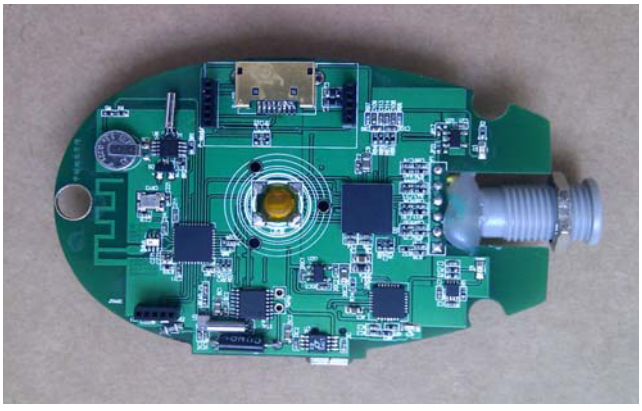

Fig.2.The 3AHcare node

Zigbee and Bluetooth are used for remote telemetry given the requirements for high bandwidth, standardized communications protocol, there are prevalence in consumer endpoints for visualization and data

relay, and the ability to interface to a large number of Bluetooth and Zigbee-enabled health devices, which can be choosed freely by wearer.

For the convenience of the wearer, the clothing (vest or bandage) used as carrier was designed for monitoring of physiological parameters, as shown in Fig. 3.

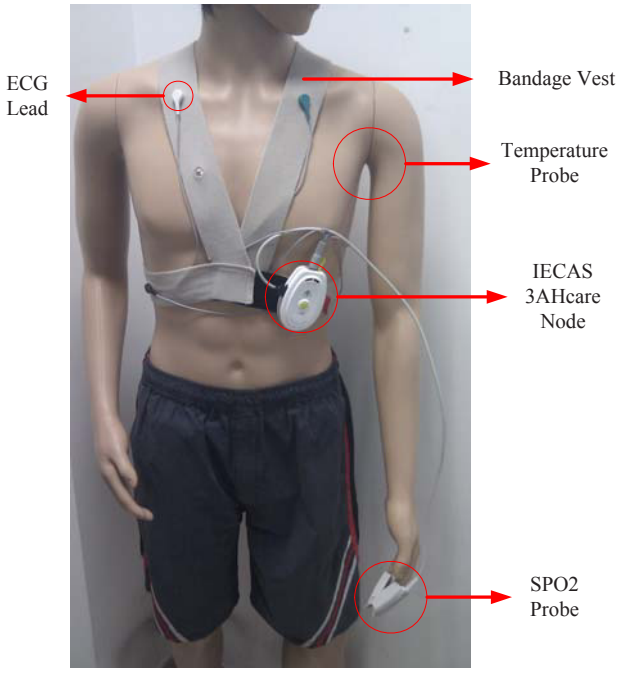

Fig.3.The Wearing Manner of IECAS 3AHcare

The collection lead is fixed on the inner side of the clothing, which is free from easy oxidation, and with high electrical conductivity, which can solve the problem of accurately positioning signal acquisition point for non-professionals and keep the signal measurement point from the consistency continuously.

The IECAS 3AHcare node is presented as platform which can enable a wide range of research and commercial applications. In this paper, we use The IECAS 3AHcare node as physiological parameters acquisition module to obtain subject's physiological parameters of ECG, blood pressure, blood oxygenation, respiration and temperature. We transmit physiological data from the physiological parameters acquisition module to the Android monitoring application via Bluetooth module embedded in the IECAS 3AHcare node.

4. The Android monitoring application

The android monitoring program of the monitoring system is developed on Eclipse 3.5.2 development environment by Java language, and is debugged and run on a smartphone with the Android operating system. The design and implementation of the Android monitoring application include two aspects: design and implementation of the android APP user interface and android APP functional modules.

Two application user interface needs to be designed in this android application, one is used for the control and operation of the application, the other one is used for displaying analog and digital forms of physiological parameters.

A series of operations on the physiological data are needed to be completed in the design and implement of the android APP function module. In accordance with the sequence of operation of the physiological parameters, these behaviors of data processing include: collection, pretreatment (separation, format conversion, calculation) , waveform and digital displaying, store, data uploading and downloading, as well as real-time alarm.

Android smartphone receive and save the physiological data sent by the 3AHcare node via its local Bluetooth, then display in real-time. At the same time, the user can perform other functions through monitoring program interface.

The System software architecture is shown as Fig 4.It is designed mainly to contain five layers: Network layer, Abstraction sensing layer, Feature layer, Inference layer and Application layer.

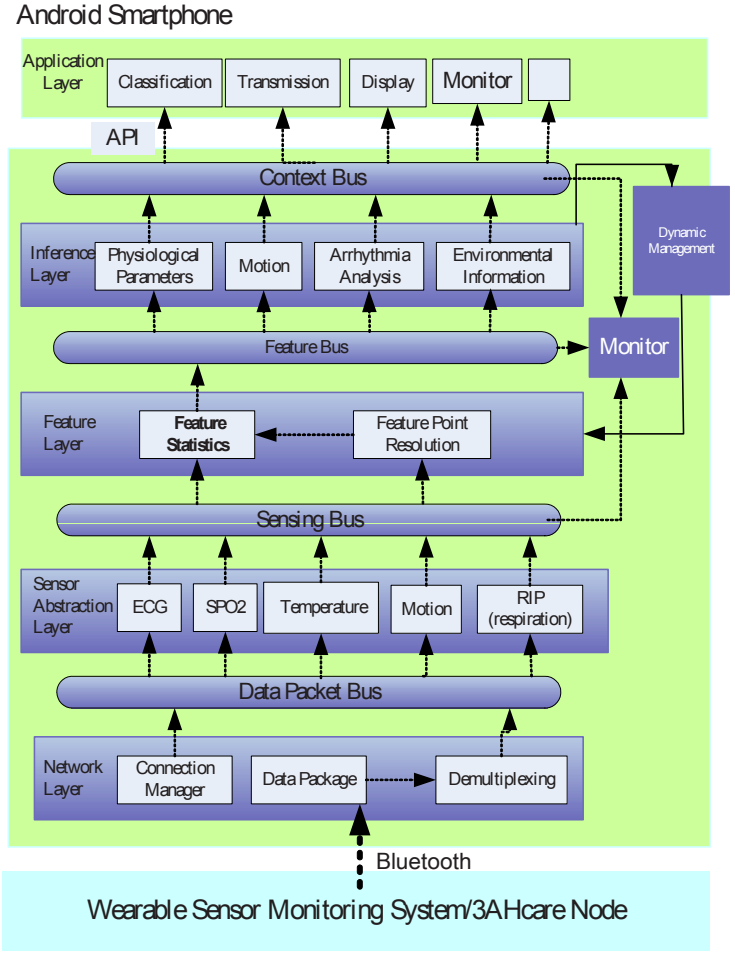

Fig.4.Monitoring system software architecture

In network layer, physiological parameters are collected and transmitted via a Bluetooth connection from 3AHcare node to a Android smartphone. In abstraction sensing layer, physiological parameters are processed adaptively, noise such as interference frequency and spurious signals are filtered, baseline drift , potential signal interference and motion artifact effect are eliminated, and different types of physiological parameters

such as ECG, oxygen, temperature are obtained. In feature layer, the corresponding position of the feature point is determined, basic values and statistical values of the feature point are calculated, and the impact of the individual differences is eliminated. In inference layer, physiological parameters, motion, ECG classification algorithm and the environment information are used to analyze the health status of the user. In application layer, physiological parameters are displayed, classified, monitored and transmitted. Besides the five layers mentioned above, a monitor is designed to be used to listening for physiological parameters of users', once physiological parameters are abnormal, it will alarm automatically.

We use the Android SDK to develop physiological parameters monitoring program in accordance with the system software architecture, each functional module is to be developed according to the different layer of the software architecture gradually.

In the network layer, physiological parameters will be collected. A Bluetooth connection is established between 3AHcare node and smartphone. Physiological data is transferred through the socket built based on the RFCOMM protocol. BluetoothServerSocket class and BluetoothSocket class can be used to create a serial communication in Android Bluetooth API. Then, a new thread in which physiological parameters will be collected periodically trough the serial communication will be created in the Android application. Physiological parameters are periodically sent from the node in the form of data packets. The data format is shown below as Fig 5:

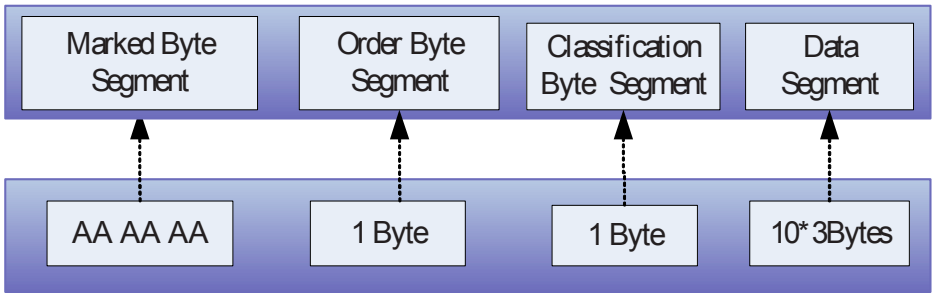

Fig.5.Data packet form

The advantages of this data transmission format are as fellow: 1. Three consecutive bytes used to represent a marked byte segment never appear again in the data segment. This makes the integrity of the packet be accurately detected. 2. Category byte segments are used to separate physiological parameters package in order to get different types of physiological data such as ECG data packets, oxygen packets and temperature data packet. 3. The three consecutive bytes in the Data segment represented a real data point increase the accuracy of collection points. 4. Order byte segment make sure that data packets are continuously accepted. 5. The periodically sending of data packets is conducive to the transmission reliability and data integrity.

Then, a data buffer pool will be created to save the received data which need to be used in the next layers of the software architecture from the Bluetooth serial port connection.

In the abstract sensor layer, some pretreatment such as separation and format conversion will be conducted. Firstly, the data package in the data buffer pool will be detected by the numbers in byte of the data package and the order byte segment of the data package. The data package will be accepted if it is integral and continuous. Secondly, data package represented different types of physiological parameters will be separated and get in accordance with the classification byte segment. Then, three consecutive bytes in data segment will

be converted to a float-type data of Java language. Finally, some algorithms such as comb filter and moving average filter will be used to eliminate noise and baseline drift.

In the feature layer, the feature points and feature value of the physiological parameters will be determined and calculated. Arrhythmia detection algorithms will be ported to the system, enabling the system to automatically carry out a variety of arrhythmia analysis an. For example, we use the Pan-Tompkins algorithm to detect QRS complexes in ECG signals and then calculate heart rate.

In the inference layer, based on physiological information, ECG analysis results and user' information of the surrounding environment, some of the results will be assessed, such as fever , early ECG abnormal ventricular contraction and atrial contraction.

In the application layer, achartengine is used to draw the waveform of various physiological parameters. Several TextView will be used to display digital form of physiological parameters. Several Button will be used to perform functions such as saving the measurement data, saving screen shots, and start measuring operation/pause measurement columns.

5. Test results

During the test, all of the electrodes of the 3AHcare node should be connected to the human body, then open the node power and Bluetooth switch. We use the user interface to the get the remote Bluetooth device and establish a Bluetooth connection as shown in Fig 6.

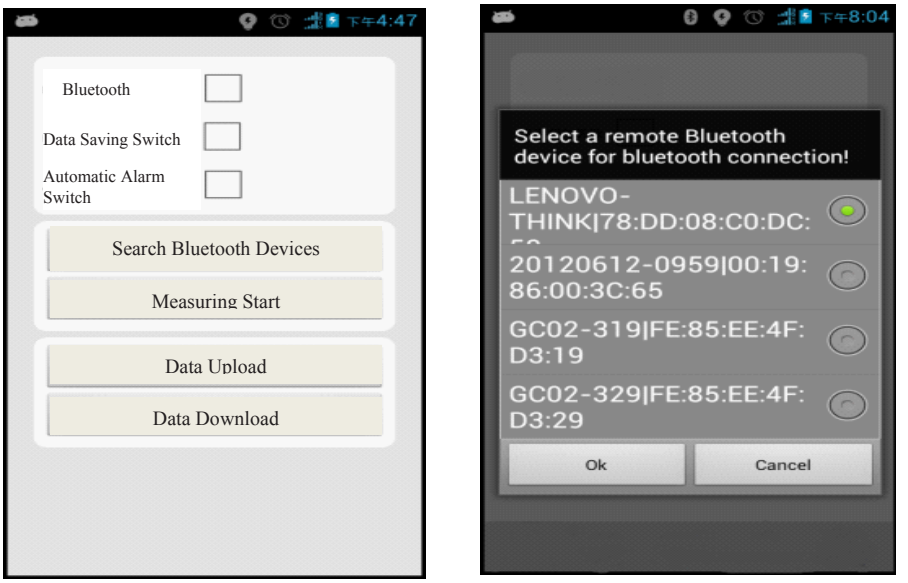

Fig.6.User Interface

We can see clearly the results of our own physiological parameters as show in Fig 7.

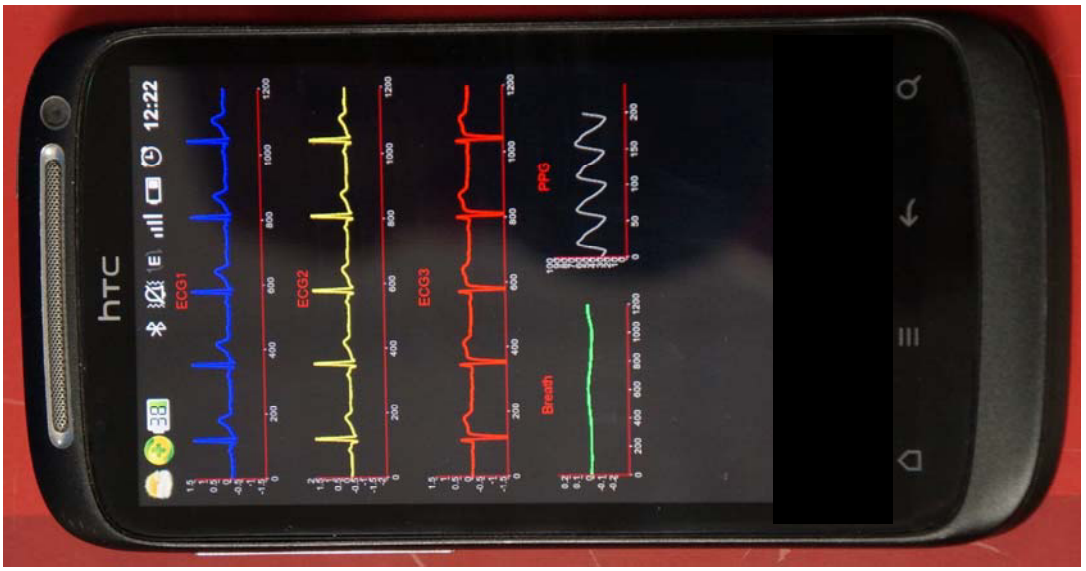

Fig.7.Physiological parameters displaying interface

6. The Conclusions

In this paper, a health monitoring system capable of detecting, monitoring and transmitting subject's physiological parameters such as ECG, blood pressure, blood oxygenation, respiration and temperature is designed and implemented. The monitoring system is small, portable, low-cost and easy-to-use without the limit of time and places. The use of Bluetooth standard communication protocol for data transmission and Android operating system for software development make the monitoring system more interchangeable. Physiological parameters can also be transmitted between Android smartphone and the remote server via WiFi or 3G, this makes a very important significance for mobile health care.

References

[1]Mohd Fadlee A.Rasid and Bryan Woodward.Bluetooth Telemedicine Processor for Multichannel Biomedical Signal Transmission via Mobile Cellular Networks[J].Information technology in biomedicine.2005.9(01),Pp.36.Mohd Fadlee A.Rasid and Bryan Woodward.
[2]Karaoguz J. High rate wireless personal area networks[J] .IEEE Comm. Magazine,2001,39(12):96-102.
[3]IEEE.P802.15-04/0137r1-2004, DS-UWB physical layer submission to 802.15 task group 3a[S].2004.
[4]Huan-Bang Li, Takizawa, K.-I, Bin Zhen ri; P. Kohno, “Body Area Network and Its Standardization at IEEE 802.15.MBAN,”Mobile and Wireless Communications Summit, 2007.16th IST, pp.1-5,1-5 July 2007.
[5]Tia Gao, Pesto C, SelavoL, etal. Wireless Medical Sensor Net-works in Emergency Response: Implementation and Pilot Results. Technologies for Homeland Security [C]. 2008 IEEE Conference on12-13May 2008: 187-192.
[6] Zhen Fang, Zhan Zhao, Fangmin Sun, etal. The 3AHcare Node: Health Monitoring Continuously. 2012 IEEE 14th International Conference on e-Health Networking, Applications and Services (Healthcom). 10-13 October 2012 in Beijing, China.