A Health Care Monitoring Terminal Based on Android Smart Phone

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***Abstract*—With the promotion of mobile communication, sensor technology and smart phone, mobile health services is developed all around the world. This paper presents a mobile health service terminal based on Android smart phone. The physiological signals are collected by body sensors and then sent to the smart phone for real-time displaying and stored via Bluetooth. Besides, it allows the smart phone communicates with the remote server. The practical applications show the terminal can be used in the mobile health services.**

Keywords—Health care, Mobile, Android, Smart phone

I. INTRODUCTION

With the rapid growth of China's economy, national life quality has been improved. However, people's health situation suffers the impact of society, economy and environment, especially for the elder one. It is known that chronic diseases are increasing year by year and national health care services are facing tremendous pressure.

In recent years, smart phone has become more and popular in people's daily life. Android phone has a very high market share with its low cost and integration of various advanced technologies such as Bluetooth, WIFI, Internet, etc. It is feasible to design a personal or home health care device which is small size, low cost and fully functional. In fact, many countries are currently carrying out research work on portable and wearable health care devices.

2014, Marcio FM Colunas and Jose M. Amaral Fernandes from Portugal Aveiro University developed Droid Jacket-a home health monitoring solution based on wearable ECG testing clothes and Android phone applications. This system can be used to real-time monitor user's physiological state, which is with good mobility and positioning function but less portable.

In May 2011, Slovenia Communications Systems Division developed a wireless ECG signal detection system based on Windows phone. By rebuilding standard 12-lead ECG signals, the analysis of diseases can be more accurate. However, its use of Bluetooth transfer control program is outdated compared to the Bluetooth module. Besides, Windows phone is less widely used than Android phone.

2010, University of Tokyo and Sony Corporation developed Smart Health Grid based on information and communication technologies. The mobile health care system can be applied in personal and home medical care, first aid and worst-hit areas etc.

2008, Huazhong University of Science and Technology developed a wearable medical care system for the monitoring of chronic diseases of the elderly population, which can detect blood pressure, ECG and other parameters, and transfer data to mobile devices via Bluetooth or USB cable. By using of3GandGPRS, it can also communicate with server. It is a full function mobile health care solution.

Health care device based on Android smart phone is rapidly developed. However, it can still be improved on the factors of function, portability, cost and consumption etc. In this paper, we design and implement a low cost, high stability, multi-function and low consumption Android based health care system, and confirm its feasibility.

II. SYSTEM DESIGN

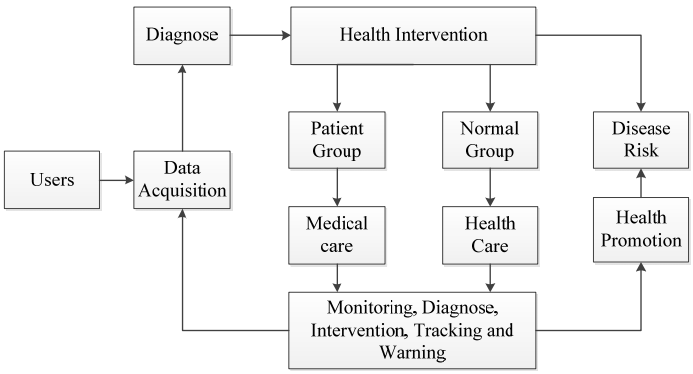

Fig. 1. Mobile health care system

Fig. 1 shows the mobile health care service. User's physiological signals such as ECG, PPG are detected by using body sensors. Data is processed and transferred to Android or uploaded to serve. Based on the diagnose result, it helps users to manage their health care. For the patient group, they need to take medical care. While for the normal group, they also need

to care about their health condition and take health care for better. Besides, it helps users to realize their disease risk. By the closed-loop service of health care monitoring, diagnose, intervention, tracking and warning, mobile health care service is provided and it may make the medical services more diversified.

A. Harware Design

Fig. 2. The schematic diagram of the healthcare system

Healthcare system mainly consists of analog front-end, Android phone and server. Fig. 2 is the schematic diagram of the health care system.

Analog front-end contains sensor probes, embedded MCU, Bluetooth module and rechargeable Li battery and other components.

Physiological signals such as ECG, PPG and respiratory signals are detected by body sensors. Patch ECG electrodes can be attached to the arms to measure single-lead ECG or attached to the chest to measure three-lead ECG signal, and the respiratory sensor is also affixed to the chest. PPG signal that contains blood oxygen information is detected by a finger type photoelectric sensor.

As the core element of analog front-end, embedded ARM MCU is used for controlling of sensors switch and signal detection timing. Signal processing and physiological parameters' calculation are also completed on the high performance MCU.

Analog front-end is powered by Li battery which can be recharged via USB. During the non-measurement period, analog front-end will automatically switch to sleep mode to save power. Users can use the device for as long time as several hours' measurement since the overall power consumption is very low.

Android phone not only roles of a user terminal to real-time display detection results, store data, and display prescription information, and also as a gateway to upload data to remote server for doctors to diagnose. In this paper, we chose Huawei X1 as the Android terminal. The parameter of Huawei X1 is as follows: 7-inch screen, 1.6GHz processor, 2GB RAM, Android 4.2 system, supporting Bluetooth and 3G networks. It is suitable for the development of the system.

Users can upload their own detection results to the server for storage and management, and download data to the Android phone for playback. In addition, the server can provides a feedback service interface which can offers users information about their health condition.

B. Software Design

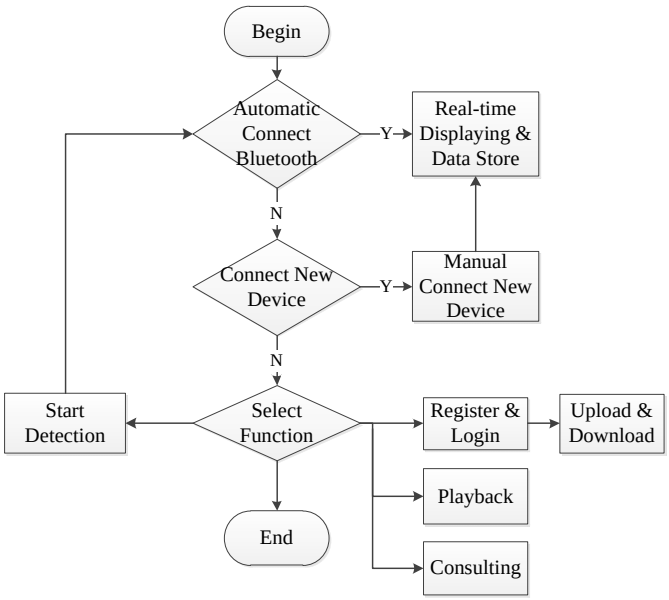

Fig. 3. The workflow of Android client

Android client is the core of the system and Fig. 3 shows its workflow.

Firstly, Android phone's Bluetooth is turned on and established a Socket connection with the analog front-end. To make it more convenient for people use, especially for those elders and poor educations, Android phone automatically try to connect with the last analog front-end device it was connected to. The automatic connection of Bluetooth is based on the stored MAC address in the Micro SD card and each time the Android phone tries the connection, it searches and matches the history MAC address. If it failed, it will establish a new connection.

While RFCOMM channel between front-end device and Android phone is established, analog front-end writes data to the output stream of the Bluetooth Socket with a customizable period and format. Android phone has to get the input stream of Bluetooth Socket, read and cache the data in local memory in a short period time within 1 second.

Real-time displaying of the detection signals is a dynamic drawing process, wherein ECG, PPG and respiratory signals are waveform displayed while physiological parameters such as heart rate, blood oxygen saturation are numerical value displayed. Android phone can provides drawing plug-in package for dynamic data processing. Processing without refresh of the graphics rendered on the interface, the continuous map is shown on the screen.

User's health data position coordinates and other information can be stored on the Android phone's SD card which can be chosen to playback, delete or automatically upload to server. To ensure the safety of data, it requires users to register for the service. Registration information includes user name, password, email, phone numbers and identification numbers. When using Android phone to access the server, the server creates a Session with a random ID for it. Android

phone can store the ID on its browser cookie or write it back to the serve through URL so that the serve can access the data saved on Android phone. User's data can be used to online diagnose by the doctors. Also, users can download their own data to their Android phone for playback. Besides, consulting services can be established through http protocol, which is similar to QQ client, simple but convenient for experience. Users can also get the medical diagnosis from the professional doctors all around the country.

C. Terminal UI Design

Android UI mainly used Activity components and each Activity component represents a screen. If see the phone as a browser, then Activity components acts as web pages. View components can be added to accomplish specific task.

Fig. 4. Terminal's main screen

Terminal's main screen consists of five Views, as shown in Fig. 4. Section A is measuring and real-time displaying interface. Section B is user center interface, users can manage their registration information. Section C is for data management. Section D and Section E are consulting and learn more interfaces.

III. RESULT AND DISCUSSION

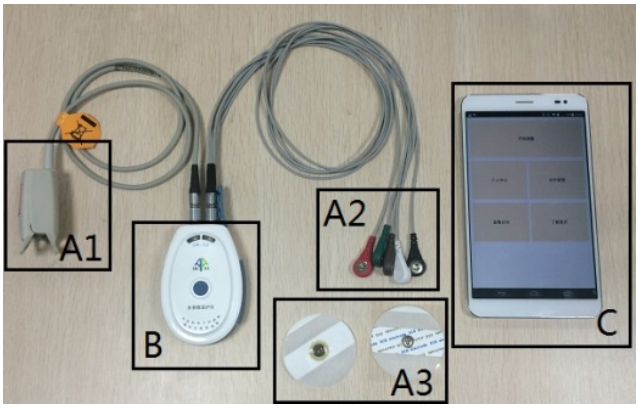

Fig. 5. Schematic diagram of the health care system

As shown in Fig. 5, A1 to A3 is PPG sensor and ECG electrodes. B is the analog front-end device. C shows the Android phone which can communicates with remote servervia3Gnetworks.

Data were acquired from five healthy male volunteers, ages 23~26.The ECG electrodes and respiratory probe were affixed to their chest and PPG sensor is clipped on their index finger stably. Subjects were seated comfortably on a chair.

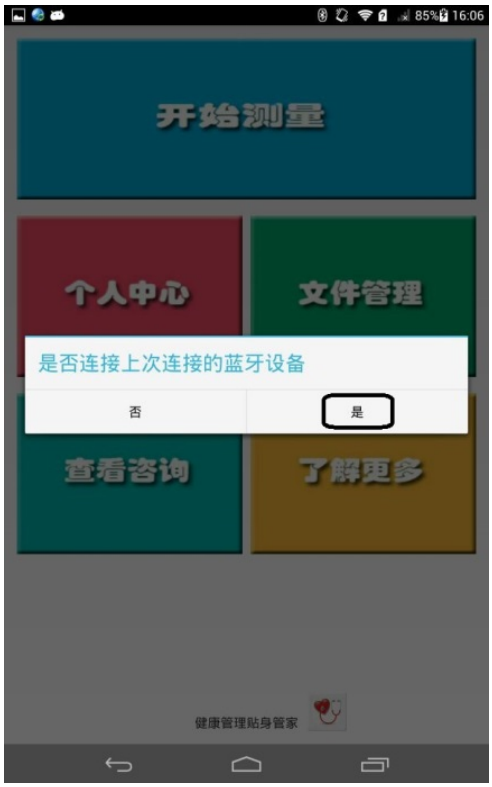

Fig. 6. Bluetooth automatic connection function

Fig. 6 shows the Bluetooth automatic connection function, which can save much time on the connection between the analog front-end and Android phone.

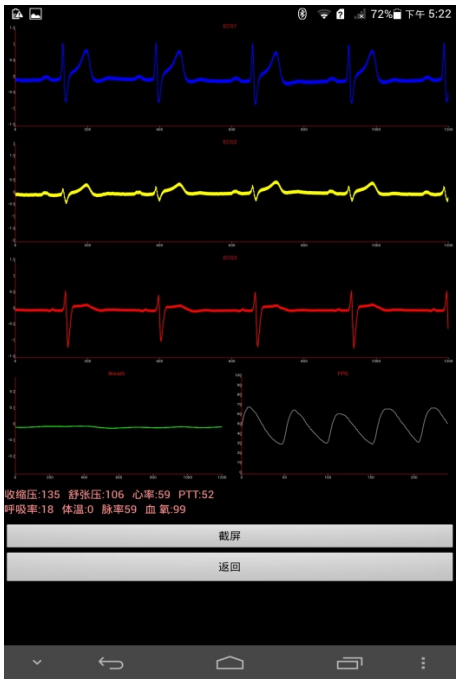

Fig. 7. Real-time displaying screen

Fig. 7 shows the real-time displaying screen. The six axes from top to button respectively represent ECG1, ECG2, ECG3, respiration and PPG signal waveform. X axis and Y axis show the time and amplitude, and their ranges can be adjusted for best displaying. The button numerical values are Systolic Blood Pressure, Diastolic Blood Pressure, Heart Rate, Pulse Transmission Time, Respiration Rate, Temperature, Pulse Rate and Oxygen Blood Saturation. Real-time displaying screen is refreshed periodically and dynamically.

TABLE I. DETECTION PHYSIOLOGICAL PARAMETERS

Parameter	SBP(mmHg)	DBP(mmHg)	HR(bpm)	SpO2(%)
Result	135	99	59	99
Mindary	125	92	59	99

TABLE 1 shows the detection result of one of the subjects, detection result which includes physiological parameters such as SBP, DBP, HR,and SpO2, which are much closed to the detection result from Mindray device.

Besides, we have successfully tested the function of downloading data from the serve and playback on the Android phone.

IV. CONCLUSION

This paper presents a health care monitoring terminal based on Android phone for mobile health care service. Physiological signals are detected and processed by analog front-end and then transferred to Android phone via Bluetooth for real-time displaying. By using 3G network, users can upload their health care data to remote server and get medical diagnosis from doctors all around the country. The automatic Bluetooth connection, simple terminal UI and others attempts make the terminal very convenient for users. The practical applications show that the terminal can be applied in the health care monitoring.

Most important, the terminal based on Android phone is small size, low cost and easily popularized, and we envisioned that this technology can benefit the mobile health care service in the near future.

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