

A Smart-Phone-Based Health Management System Using a Wearable Ring-Type Pulse Sensor

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Abstract. In this paper, a mobile e-health-management system is presented which extends authors' previous works on mobile physiological signal monitoring. This system integrates a wearable ring-type pulse monitoring sensor with a smart phone and provides a mobile "exercise-333" health management mechanism. All physiological measurements are transmitted to the smart phone through Bluetooth. The user can monitor his/her own pulse and temperature from the smart phone where the health management mechanism helps him/her to develop a healthy life style: taking exercise 3 times a week and at least lasting for 30 minutes with heart rate over 130 each time. With the popularity and mobility of smart phones, this system effectively provides the needs for mobile health management.

Keywords: health management system, smart phone, Bluetooth, RFID, GPS.

1 Introduction

"Prevention is better than cure." The system proposed in this paper aims to achieve this. At the end of 2008 the elder population was 2.4 million in Taiwan, according to the bulletin report of Taiwan Ministry of Interior, and it was about 10.4% of the total Taiwan population. This percentage has already exceeded the standard for aging society set by the World Health Organization (WHO). It is estimated that in 2025 the elder population in Taiwan will reach more than 20% of the total population and the market revenue of home health care for these elders would reach 300 million dollars in 2010. The "long-distance home health care service" has thus become one of the key emerging businesses in Taiwan.

In recent years, several studies integrating communication and sensor technologies for home health monitoring system have been discussed [1-18], such as monitoring long-term health data to find out the abnormal signs and monitoring the medical record regularly for chronic patients to cut down their treatment frequency, to save doctor's treatment time, and to reduce medical expenses. Based on the sensor and communication technologies used, these systems can be categorized into two systems: immobile and mobile long-distance health monitoring systems. Our previous works [13]-[18] all focused on mobile long-distance physiological signal measuring based

on either a single-chip-microprocessor [13]-[15] or a smart phone [16]-[18]. The physiological sensor used was a RFID ring-type pulse/temperature sensor. The measured data can be transmitted via different communication protocols, such as Bluetooth, ZigBee, HSDPA, GPRS, and TCP/IP. In order to meet the requirement for mobile health monitoring system (MHMS), the system design needs to adopt light modular sensors for data collection and wireless communication technology for mobility. The popular smart phones used in people's daily life are the best devices for MHMS.

In this paper, a mobile e-health-management system is presented which extends authors' previous work [13]-[18] on mobile physiological signal monitoring to practice the idea of "Prevention is better than cure." This system integrates a wearable ring-type pulse monitoring sensor with a smart phone and provides a mobile "exercise-333" health management mechanism. The user can monitor his/her own pulse and temperature from the smart phone where the "exercise-333" health management mechanism helps him/her to develop a healthy life style: taking exercise 3 times a week and at least lasting for 30 minutes with heart rate over 130 each time. With the popularity and mobility of smart phones, this system effectively provides the needs for mobile health management.

2 System Architecture

For the descriptive purpose, the monitoring system proposed in [16]-[18] is presented here again. Fig. 1 is the system architecture where the ring-type sensor measures pulse/temperature and transmits the physiological data to the reader using wireless RF, the Bluetooth connected to the reader then passes the data to the smart phone, and the smart phone collects/displays the physiological data and also transmits data to the remote medical station using GPRS, HSDPA (3.5G), WiFi, or WiMax. The GPS built in the smart phone can provide the position information of the monitored person so that the medical personnel can be dispatched to the right location more promptly in an emergency situation. Figs. 2-5 show the photos of RFID pulse/temperature sensor tag (Ring), RFID reader, Bluetooth RS232 adaptor, and the integration of Bluetooth adaptor, RFID tag (Ring), and RFID reader, respectively. This ring sensor developed by Sinopulsar Technology Inc. is non-invasive, portable, and mobile. It can measure pulse and temperature signals which are processed by a built-in microcontroller. It uses optical sensor to detect heart rate and has anti data collision mechanism. Physiological data are then transmitted by RF wireless transmission with FSK modulation using UHF ISM band (up to 50 meters) to its RFID reader with a RS232 port. The data communication between RFID reader and the smart phone is through Bluetooth. HL-MD08A (Bluetooth RS232 Adaptor manufactured by Hotlife Technology) is used in this system. It supports a wide range of Baud rates from 1.2K to 921.6K bps. Fig. 6 shows the photo of the smart phone (ASUS P552W) used in this system. Its operating system is Windows Mobile 6.1 operating system with built-in GPS, and it supports HSDPA 3.6Mbps, EDGE, GPRS, and GSM 900/1800/1900. The screen in Fig. 6 depicts the physiological data monitoring GUI where two temperature values measured by RFID reader and Tag and pulse data are shown.

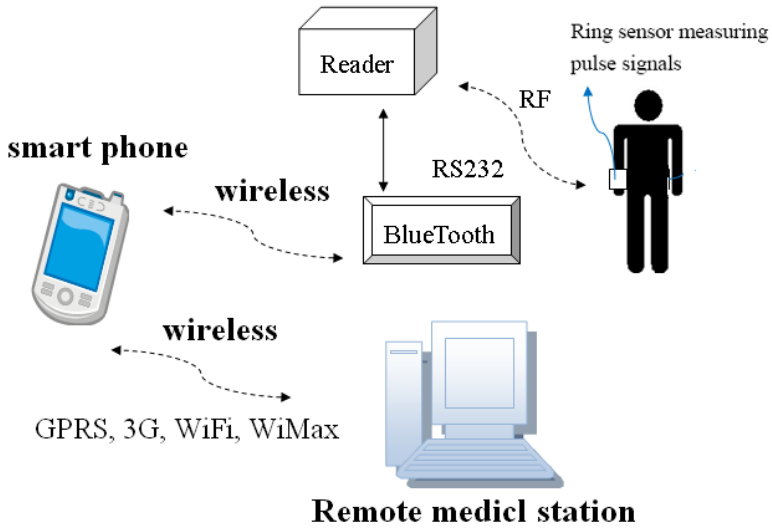


Fig. 1. MHMS Architecture

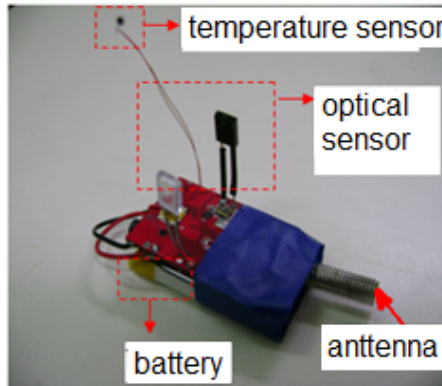


Fig. 2. RFID tag (Ring)

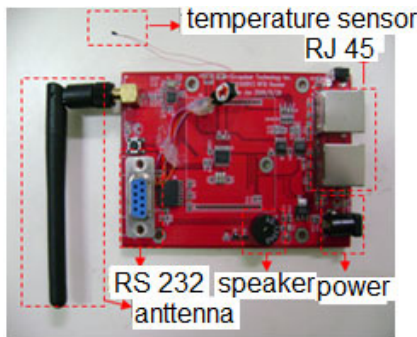


Fig. 3. RFID reader

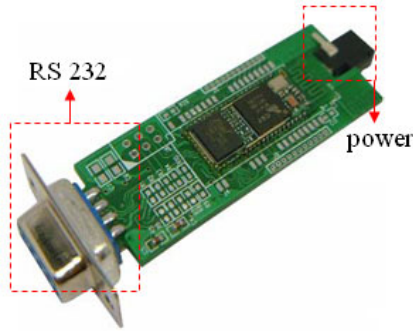


Fig. 4. Bluetooth RS232 Adaptor

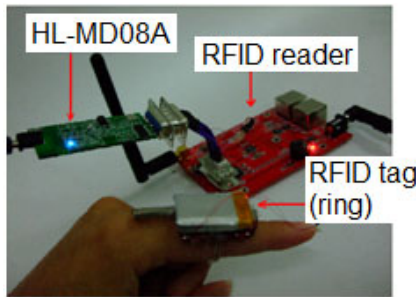


Fig. 5. Bluetooth adaptor, RFID tag (Ring) & RFID reader



Fig. 6. ASUS P552W smart phone

The GUI programs developed on the smart phone and on the remote medical station were coded in Visual C#. Microsoft .Net compact framework 3.5 was installed on the smart phone for running the client APs, and Windows Mobile 6 SDK, smart phone emulator, and Cellular Emulator were installed on the PC for developing the client APs.

Fig. 7 depicts the physiological data monitoring GUI on the smart phone emulator (on PC side), which is the same GUI shown on the smart phone screen in Fig. 6. The SOS message box indicates the status of the SOS button on the ring Tag. If this button is pressed, the smart phone will dial the pre-set emergency phone number(s) to send out SMS with the GPS position information to other people for help. Fig. 8 presents the 3G communication setup page of the smart phone and the webpage of remote medical station. The 3G connection setup page of the smart phone is shown on the left side and the webpage of the server is on the right side where temperature values, pulse, and Google map are displayed. Based on the GPS position information sent from the smart phone, the Google map helps the medical staff to locate promptly the monitored user who needs further assistance.



Fig. 7. Physiological data monitoring GUI



Fig. 8. 3G communication setup and the webpage of remote medical station

3 333 Health Management Mechanism

Compared to the traditional medical care that people receive medical treatment after they feel ill, an effective health management program can provide prevention of illness in a more aggressive manner—prevention is better than cure. Especially for

people working in present modern high-tech society under lots of pressures and lacking exercise, such a preventive health management becomes essential. According to the report conducted by a hospital in Taiwan [19], exercise-333 can effectively prevent cardiovascular diseases. The concept of “exercise-333” is quite simple; i.e., taking exercise 3 times a week and lasting for more than 30 minutes with heart rate over 130 each time. The health management mechanism developed in this paper, based on the system architecture discussed in Section 2, can help to remind the user to develop such a healthy life style.

Fig. 9 depicts the exercise-333 health management GUIs on the smart phone. In the first GUI, the user can set up 3 weekdays as checking points and at each checking point it will show the progress status to remind the user. In the second GUI, at the end of each day it will show the user whether his/her heart rate has ever been over 130 for more than 30 minutes. And at the end of each week, this GUI also shows the condition whether the user has accomplished exercise-333. With these two smart-phone GUIs, the user can constantly receive reminders and check his/her exercise status. Based on the fact that in Taiwan every 100 people have 108 cellular phone numbers [20], the high popularity of smart phone makes the presented health management system effective and convenient to help people on developing a healthy life style.

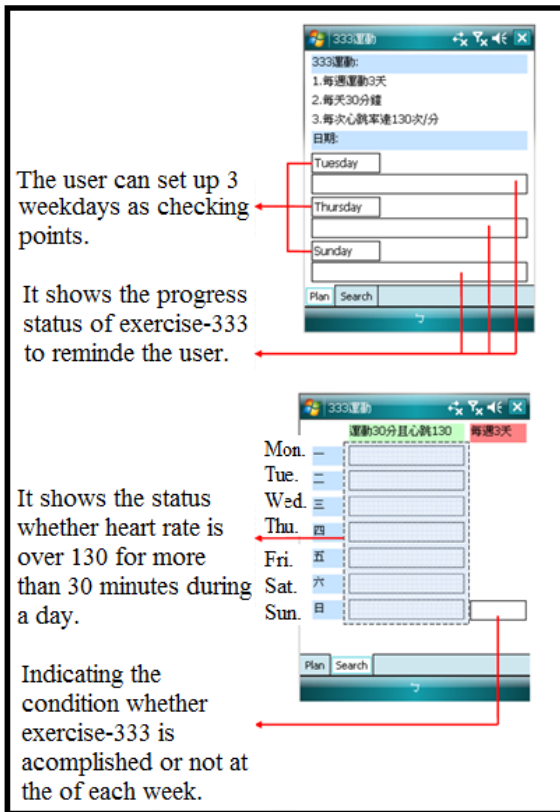


Fig. 9. Exercise-333 health management GUIs

4 Conclusions

In this paper, a mobile e-health-management system has been presented. This system is an extension of our previous works on mobile physiological signal monitoring and practices the idea of “Prevention is better than cure.” The presented system consists of a wearable ring-type pulse sensor and a smart phone to provide a mobile “exercise-333” health management mechanism. The user can monitor his/her own pulse and temperature from the smart phone where the “exercise-333” health management mechanism helps him/her to develop a healthy life style: taking exercise 3 times a week and lasting at least for 30 minutes with heart rate over 130 each time. With the popularity and mobility of smart phones, the presented system effectively provides the needs for mobile health management.

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