Seamless Personal Health Information System in Cloud Computing

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***Abstract*—Noncontact ECG measurement has gained popularity these days due to its noninvasive and conveniences to be applied on daily life. This approach does not require any direct contact between patient's skin and sensor for physiological signal measurement. The noncontact ECG measurement is integrated with mobile healthcare system for health status monitoring. Mobile phone acts as the personal health information system displaying health status and body mass index (BMI) tracking. Besides that, it plays an important role being the medical guidance providing medical knowledge database including symptom checker and health fitness guidance. At the same time, the system also features some unique medical functions that cater to the living demand of the patients or users, including regular medication reminders, alert alarm, medical guidance, appointment scheduling. Lastly, we demonstrate mobile healthcare system with web application for extended uses, thus health data are clouded into web server system and web database storage. This allows remote health status monitoring easily and so forth it promotes a cost effective personal healthcare system.**

I. Introduction

The prevalence of chronic diseases such as obesity and various heart diseases has risen all over the world. Heart attack is a serious phenomenon in the society nowadays. People who have had a heart attack have a sudden death rate that is 4 to 6 times that of the general population [1]. Thus, real time and long term health care monitoring system has gained much attention nowadays to ensure people are aware of the warning signs. However, the rise of health care financial costs has become a huge challenge to governments, health organizations and public citizens. It is indicated that 16% of GDP is spent on health care on 2009 in the US [2]. Consequently, many people are not willing to seek medical help until their situation is worsened.

Various health monitoring devices have been commercialized for public uses such as ECG belt [3], accelerometer, SpO_2 sensor, blood pressure wristband, and pulse oximeter. However, these physiological signals are not being monitored in real time and it delays the chances of rescuing heart attack patients. Thus, with the development of the technologies such as mobile computing, wireless sensor network and web server clouding system, the required medical care and medical consultation can be provided easily and remotely. The advance information and communication technologies in medical healthcare service [4] not only to reduce consumed manpower and medical health care cost but also to achieve real-time medical care service and to provide advanced care to remote locations.

Mobile health care system enables remote monitoring and web server clouding system enables remote data collection. This system utilizes mobile device to display and transmit physiological signals such as ECG signal and heart beat rate. Then, health information are collected and synchronized to web server through Wi-Fi or data communications. Therefore, raw health data are stored in cloud storage to enable professional medical or nursing personnel to access and analyze the monitoring results and so forth provide appropriate care services.

II. System Architecture

The overall system architecture of mobile health care system for noncontact healthcare monitoring system is shown in Fig. 1. The system comprises of a noncontact ECG measurement system (a pair of capacitive electrode on chair back and a piece of conductive textile on chair seat) [5-6], an electronic sensor module, an Arduino Bluetooth module for physiological signal transmission, mobile device with Bluetooth API for data reception and real-time health status displaying, and lastly a web server system for monitoring service and medical data cloud storage.

III. Sensor and Mobile Communications

In mobile medical health care system, conductive

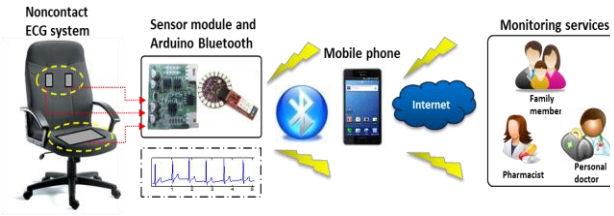

Figure 1. The seamless healthcare system architecture.

electrodes sense physiological signal from user body; sensor module plays an important role for analog signal filtering before a clear physiological data is transmitted to mobile device. Then, physiological data is transmitted via mobile communication. Mobile communication happens between Arduino Bluetooth and mobile Bluetooth.

A. Sensor Module, Arduino and Bluetooth Communications

Sensor module mainly utilizes a bio-sensor. The capacitive-coupled electrodes measure the capacitance of the capacitive coupling involving a conductive electrode, an insulator, and the skin of the subject [6]. Our method is operationalized through a pair of capacitive coupled

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electrodes installed on the chair back and conductive textile installed on the seat for capacitive driven-right-leg (DRL) grounding. The capacitive electrodes are connected to an electronic circuit includes high input impedance amplifiers and band-pass filters for analog signal processing. Low pass filter and high pass filter are designed to eliminate analog noise. Notch filter is used to filter 60Hz power line noise.

Arduino Bluetooth is a microcontroller board based on the ATmega328 with built-in Bluetooth module, allowing for wireless communication with computers, phones and other Bluetooth devices. In this system, after the analog physiological signal is preprocessed by sensor module, microcontroller digitizes the analog signal by an Analog-to-Digital converter. Then, the digitized physiological signal is processed and encapsulated into packets which are transmitted via Bluetooth to mobile device.

B. Mobile Bluetooth Communication

At the mobile side, the android platform includes support of the Bluetooth network stack, which allows a device to wirelessly exchange data with other Bluetooth devices. To use the Android Bluetooth APIs to accomplish the four major tasks are necessary to communicate using Bluetooth: setting up Bluetooth, finding devices that are either paired or available in the local area, connecting devices, and transferring data between devices [7]. In our system, Android Bluetooth is paired with Arduino Bluetooth; physiological data are being transferred digitally from Arduino to mobile for real-time monitoring and displaying purposes.

IV. Mobile Healthcare System

Mobile devices are evolving at a rapid pace in the deployment of health care environment. Our system is mainly based on the current real-time long term health monitoring, catering for the demand of assisted living and health fitness information provider.

A. ECG Signal by Noncontact Method in Different Subjects

ECG measurements have been done on 5 subjects. The ages of the subjects are very between 21 to 52 years old. Both women and men participated in the experiment. Figure 2 shows recordings typical of those obtained. The ECG signals from capacitive non-contact ECG measurement with the FEEP shows clear ECG signals. As shown in Figure 2, the periodic R-wave was evident in all recordings.

B. Location Tracking

Physiological signals are being monitored in real-time. However, the location of user is unknown. It is imperative to implement location tracking as if medical emergency happens; rescue and help should be provided immediately. By tracking the location of the user, immediate rescue can be provided without much delay. Thus, the surviving rate will be higher. Location tracking is used to get real-time location of the elderly or patients so that they can be found immediately when detecting emergency.

C. Medication Tracking and Reminder

Real-time health monitoring is important. At the same time, elderly patients may call for a life assistant due to their physical status of discomfort and decline in life skills such as visual and mobility decline or memory loss. Therefore, our system offers an auxiliary function for medication tracking and reminder. Considering that the memory power of the elderly is poor, regular reminder can remind the elderly to take medicine at certain time. Besides that, it is very useful for workaholic or busy person who works very hard trying to catch up at this rat-racing society, very often, they forgot their medication prescription.

D. BMI Calculator

Obesity, hypertension and type 2 diabetes has become pediatric problems nowadays. To ensure a healthy body, it is important to monitor and tracking a BMI of a person. Body mass index (BMI) is a measure of body fat based on height and weight that applied to both adult men and women. It generates a number which shows whether a person is underweight, optimal weight, or various degree of obesity. A BMI of 30 of more is considered obese. Being obese increases the risk for serious conditions such as heart disease diabetes, and high blood pressure. Thus, BMI calculator in our system helps to measure and ensure a healthy weight with corresponding height at an early stage before obesity creeps in. In this situation, patients or users will be aware of their health status. BMI is calculated as in (1).

$$BMI = \frac{Weight\ (kg)}{Height\ (m) \times Height\ (m)} \tag{1}$$

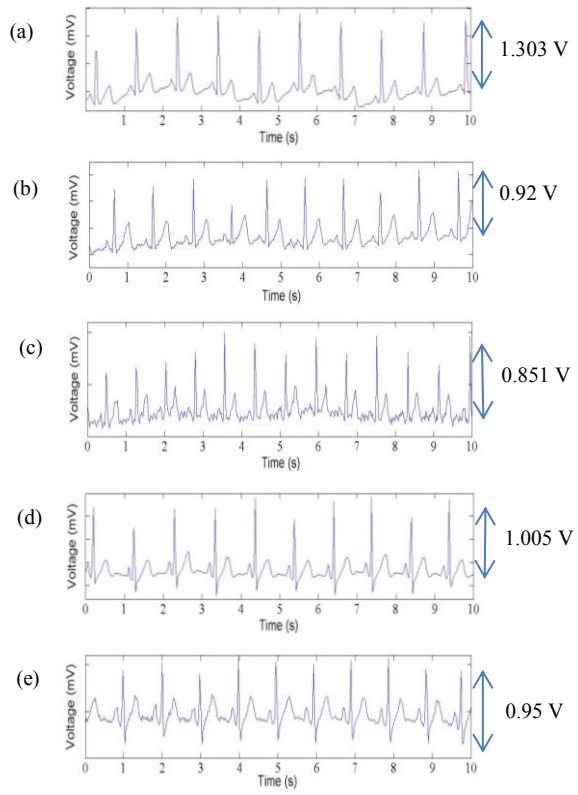

Figure 2. ECG recordings obtained from different subjects by noncontact ECG measurement method; (a) 40-year-old woman, (b) 21-year-old woman, (c) 52-year-old man, (d) 39-year-old man, (e) 22-year-old man.

E. *Symptom Checker*

Symptom checker is designed to let users or patients to check out medical symptoms to find common causes, a possible diagnosis, and provide trusted information for treatments and prevention. The system will provides several suggestions of what could be wrong and help the user to decide if he needs to see a doctor. Symptoms information and guidance database are retrieved and searched locally on mobile device for fast response in this system.

F. *Warning and Notification*

This system collects physiological signals and transmits them to mobile phone and alarms automatically to the emergency center or pre-assigned people when data exceed the threshold of the fixed device. The emergency center will call an ambulance to the current location by checking the real-time location.

V. Web Application Clouding System

This system acts as the personal health information system. The mobile device gets physiological data from sensor electrodes, and locally stores and processes physiological data and other health information such as medication tracking and alarm reminder, symptom checking information. Mobile device will send these data in bulk to the web server and the web server stores them in web database for health information clouding and synchronization. Physicians, families and friends of the users whose permissions are granted can access to view the current and history medical information by one click through internet connectivity. Thus, professional personnel can monitor the health condition of users as well and alter related threshold so that dynamic monitoring is guaranteed.

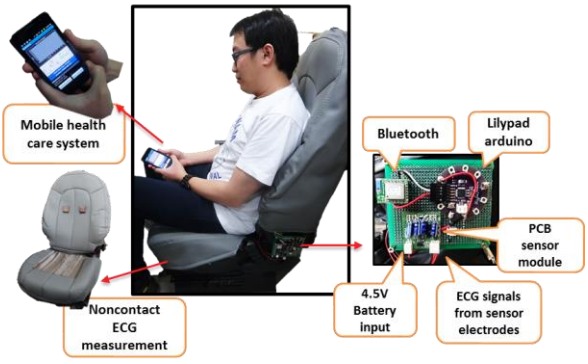

Figure 3. System implementation.

VI. Implementation Results

Our system acts as a mobile health care monitoring system with taking into consideration providing several functions as life assistant. System implementation is shown in Fig. 3. A user wore a cotton shirt, sitting on a chair seat with conductive sensor electrodes installed on it. Together with a sensor module, battery supply, Arduino and Bluetooth module are attached beside the chair seat. User is holding the mobile device for real-time health status monitoring. ECG signal is measured from the subject through a cotton shirt. Then, ECG signals from sensor electrodes are being filtered in PCB sensor module. Arduino Bluetooth is connected together with sensor module for data communication to mobile phone. A 4.5V battery input is supplied to both sensor module and Arduino Bluetooth module. And lastly, mobile application is built for real-time health monitoring.

A. *Main Interface*

The application on mobile device displays several auxiliary functions for medical healthcare monitoring and living assistant. Fig.4 shows the main interface of the mobile device application.

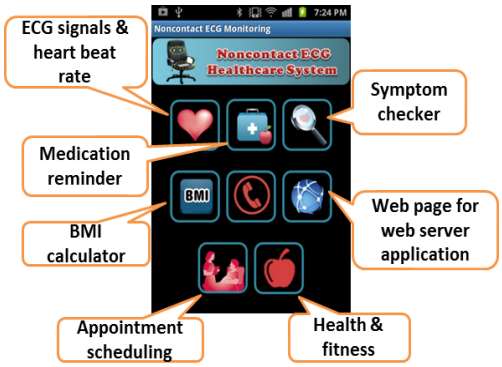

Figure 4. Main interface on mobile device.

B. *Real-time medical health monitoring*

The real-time medical health monitoring can monitor real-time ECG signals and heart beat rate of the users. At the same time, the real-time location is being tracked via GPS as well for immediate emergency rescue. When real-time health monitoring activity starts, mobile device connects to a pre-assigned Arduino Bluetooth module, it receives physiological data from Arduino Bluetooth and processes them to calculate the heart beat rate. Fig. 5 shows the real-time medical health care monitoring interface. It displays the real-time ECG signals, heart beat rate and current location.

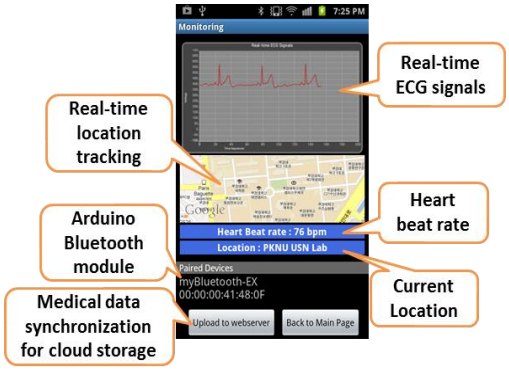

Figure 5. Real time medical health care monitoring.

C. *Medical health care assistant*

Medical health care assistant is important to ensure a healthy lifestyle and healthy body. The application on mobile device enables users to calculate their BMI for a healthy weight monitoring and tracking. This is helpful to prevent obesity

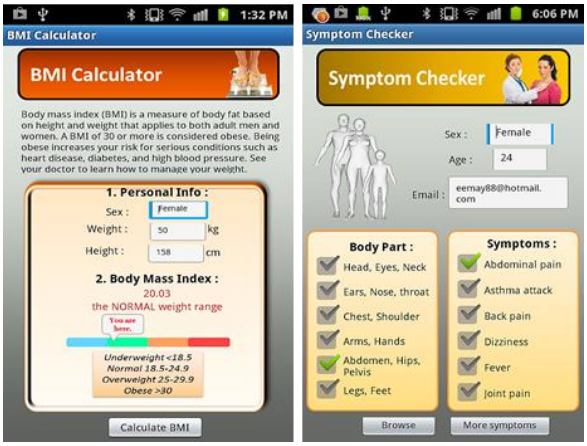

Figure 6. (a) BMI calculator. (b) Symptom checker.

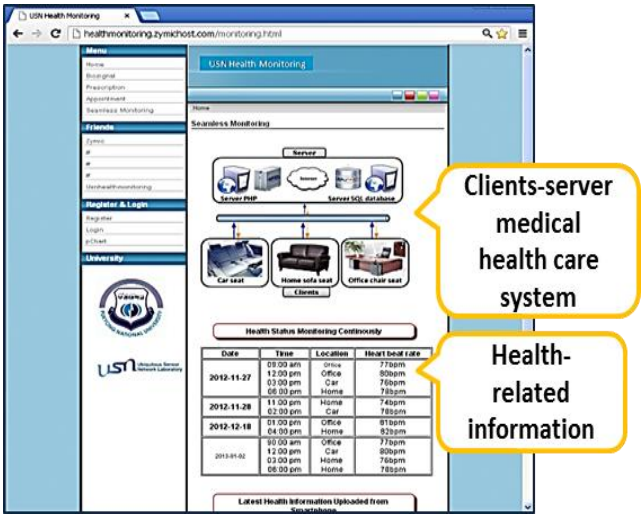

Figure 7. Web application medical health care system.

and reduce the risk of heart diseases. Fig.6 (a) shows the BMI calculator for BMI monitoring by entering height and weight of the user. At the same time, users can check for disease symptoms for early disease diagnosis through symptom checker function on mobile device. Fig.6 (b) demonstrates the symptom checker function where user can browse according to symptoms or body parts.

D. Web Application Medical Health Monitoring

The web server application acts as the personal health information system in which physiological signal and other health-related information can be stored and users can check any medical records. Fig. 7 illustrates the web server page for medical health data synchronization and tracking.

VII. CONCLUSION

A mobile medical health care system is designed with noncontact ECG monitoring in a simple and cost-effective way. This system can not only dynamically monitor health-related information anytime and anywhere but also acts as an important medical living assistant. Real-time ECG signals, heart beat rate and current location are monitored on mobile device. At the same time, the system provides function for weight tracking and management to achieve a healthy body mass index. This system also ensures user has their prescription intake regularly. Lastly, web server application acts as the personal health information system which allows medical data synchronization and cloud storage purpose. It also allows professional personnel to view current and previous health-related information in a very convenient way. Therefore, any advice or feedback from professional personnel can be given immediately. This system can be applied for the managements of weight-loss, exercise and usual healthcare service until it receives certification by the medical service law.

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