Integration of Wearable Monitoring Device and Android Smartphone Apps for u-Healthcare Monitoring System

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Abstract

The U-healthcare System is an interesting new technology that needs an extra attention from the researchers and developers. There have been a lot of researches on how to integrate the new technology to maximize the use to enhance the healthcare system but there is no specific research how it is to be done in a way that this is reliable and cost effective to the end users. This study is focused on the integration of wearable monitoring device and Android smartphone Apps for u-Healthcare Monitoring System. This study proposes a system u-healthcare monitoring system which is convenient and just in the reach of hand of the users. The integration of wearable monitoring device (IEEE 11073-20601 Stack), Bluetooth and Android Apps are the technologies used in this study.

Keywords: U-healthcare, IEEE 11073-20601 Stack, Bluetooth and Android Apps

1. Introduction

Ubiquitous healthcare is an emerging technology that promises increases in efficiency, accuracy and availability of medical treatment. The purpose of u-healthcare monitoring system is to provide convenient healthcare service to both caregivers and patients, and to make it easy to diagnose patient's health condition. People can monitor their health without visiting the hospital or clinic. Hospitals can provide patients with efficient medical services through computerized medical information and resources. Moreover, healthcare systems in developing countries confront serious difficulties in providing care and assistance, mainly due to scarcity of personnel and resources. Information and communications technologies appear in this context to revolutionize this field and to provide innovative, efficient, and affordable solutions.

Ubiquitous Healthcare system means the environment that users can receive the medical treatment regardless of the location and time. As the quality of the life has been improved, we are more focusing on our health and people want to be treated with the arising trend of the Ubiquitous. With the advent of the new technology, the interest of the remote treatment has been increasing. So, Systems are developing that can check their health status and treat them in a distance in a real time. Now, we are asking more services that can detect patient’s location and utilize this information. This system is the service which can help to detect the location of people or things through the portable-equipment based on wireless communication network. With this system we can process and manage data at the hospital or Emergency room in a distance by transferring bio-data such as ECG data and pulse data as well as the user's location information.

Ubiquitous healthcare systems will monitor patients as they maintain their normal everyday activities, in order to warn the patients or healthcare workers of problems as well as collecting data for trend analysis and medical research. The continuous monitoring of the health record would give a better diagnosis. The integration of wireless body sensor

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network is very important for timely monitoring.

Although these innovative tools are truly interesting to promote a more personalized and independent healthcare, a crucial aspect that may not be approached through web technologies is corporeal monitoring. Body monitoring deepens into the patients’ physiology, biological conditions, and behavioral aspects, which are utterly necessary to have a precise understanding of their status and particular necessities. According to the traditional health care model, patients’ monitoring is normally relegated to sporadic doctor visits or institutionalization, which goes against the principles of proactivity, independence, accessibility, and cost-effectiveness. Oppositely, embracing these principles arises mobile Health (mHealth). mHealth is an emerging and rapidly developing field that builds on a wide range of mobile technologies such as smartphones, tablets, and portable health devices to support community and clinical health data retrieval, delivery of healthcare information, or direct provision of care [2].

Nowadays there are a lot of smartphone applications which are used in medical application. This study focused on how to utilize different smartphone apps in u-healthcare system implementation.

2. Background of the Study

This section discusses the background of the study. The smart mobile apps and their healthcare application; and the wearable sensor devices.

Smart, easy to use, cloud-connected and multi-function medical health sensors that can capture a rich set of physiological and biological parameters are now a reality and bring medical monitoring to a whole new level. These advances will revolutionize the medical practice of preventive care and foster a new era in medical devices. Algorithmic, circuit, and form factor innovations, coupled with integration and miniaturization of sensors, along with intelligent usage feedback mechanisms using devices are the driving forces behind the technology advances in medical monitoring. Quality of care can now be drastically improved by use of these sophisticated at point-of-care devices, serving a multitude of medical market segments such as (i) elderly managed care, (ii) chronic disease care, (iii) hospital discharge care, (iv) telemedicine, to even (v) average consumers who want to be empowered to better understand their health in collaboration with their physicians and care providers. This talk will provide an overview of this topic, as well as the relevant opportunities for device and sensor makers.

2.1 Smart Mobile Apps and their healthcare application

The advances in mobile technology have opened new ideas in maximizing its usage. There are many Smart Mobile Apps developed and free to use by smart mobile users.

**Heart rate.** There have been developed smartphone apps that were used to check the heart rate. Want to check your heart rate but don’t feel confident measuring your pulse? Several apps turn your phone into an automated pulse checker. For example, Instant Heart Rate, from a company called Azumio, uses a phone’s camera to measure how fast the heart is beating.

**CPR guide.** If you see a person suddenly collapse with a cardiac arrest, the best things you can do for him or her are call 911, send someone to find an automated electronic defibrillator, and start cardiopulmonary resuscitation (CPR). An app from the American Heart Association, called Pocket First Aid & CPR, can guide you through the steps of performing CPR and using the defibrillator. It also includes in-depth information for other health emergencies.

**Blood pressure.** Blood pressure is one of the primary vital sign which is the basis if there is a health problem. As more and more people measure their blood pressure at
home, apps are springing up to help. Early ones allow a user to enter blood pressure readings from which the app makes graphs and offers suggestions. Withings Company has developed a blood pressure cuff that completely automates the process. After the cuff takes your blood pressure, it saves the measurement to your phone and sends it to an online database that you can access with any computer connected to the Internet. You can track the ups and downs of your blood pressure or send the measurements to your doctor [4].

Today’s apps offer only a hint of how smartphones will eventually be used in health care. Wireless devices like bathroom scales and blood pressure monitors programmed to communicate with a smartphone can alert an individual with heart failure and his or her medical team that trouble is brewing. Wearable sensors that constantly track the heart rate or rhythm could sound an early warning about an impending heart attack. Apps and their gadgets are becoming so sophisticated and powerful that the FDA has announced its intention to regulate ones that are meant to be used with an FDA-regulated medical device (like a blood pressure cuff), or ones that turn a mobile device into a regulated medical device (like an electrocardiography machine).

2.2 Wearable Sensor Devices

There are types of wearable sensor devices; this can be in form of wrist watch type, shoulder type, chest type and necklace type. The wearable sensor device is used to get heartbeat rate, blood pressure and other kind of health status related monitoring signs.

There are several wearable sensor devices that can be used in ubiquitous healthcare especially in monitoring the health status of the patient while they are away from the hospital and even in the hospital. Body area networks, wireless body area network or body sensor network are terms used to describe the application of wearable computing devices. This will enable wireless communication between several miniaturized body sensor units and a single body central unit worn at the human body.

![Figure 1. Wearable Sensor Devices](image)

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3. Android Smartphone Apps for U-healthcare System

1. A wearable monitoring device that records different types of physiological data on a subject and transmits them wirelessly;
2. A mobile device, for example, smartphone, which runs an app that acts as collector of the data delivered by the vital sensor, support system for medical diagnosis and health alerts, interface for user data inspection and gateway to forward the data to a remote storage for further analysis;
3. A remote persistent storage system to store data from multiple users, particularly devised to support advanced health services and analytics.

3.1 Android Applications for Bluetooth Health devices

Many healthcare providers are adopting Smartphones successfully in a diverse range of practices [3]. Several reasons make Smartphones attractive to healthcare providers. The primary reason is that many POC Smartphone apps have been developed. The second reason is that healthcare providers are mobile workers and a Smartphone provides a huge amount of information at their fingertips no matter where they are. Even when a healthcare provider is in his office, he is moving around a lot, not really stationed at his computer. Further, the multiple media aspects of Smartphones, along with connectivity and mobility can help a healthcare provider become more efficient. Meanwhile, patients are also getting used to accessing health information, actively participating in their own healthcare, and maintaining contact with their healthcare providers through Smartphones. In particular, chronic conditions such as diabetes, mellitus and cardiovascular disease, are perceived as a special niche market for Smartphone apps. Therefore, Smartphones are starting a new epoch in healthcare, and there are significant opportunities to exploit the potential of Smartphones in healthcare [3].

The data measured through the Wearable Monitoring Device is further transmitted to a mobile device (e.g., smartphone or tablet). In particular, Android devices have been here considered. Several advantages of the Android operating system with respect to its competitors were conclusive during the platform selection. These include the greatest growing mobile market, open source framework, highest performance stability and security, and continuous updates and upgrades of the application programming interface (API), among others. Different mobile devices have been tested during development and validation of the system, including Samsung, HTC, LG, or Sony devices for a representative selection of the various Android API available versions. Since Android Ice Cream Sandwich (Android 4.0, API 14), we can develop Android applications for Bluetooth Health devices.

The official Android Developer site indicates that the BluetoothHealth API allows communication with devices that implement the Bluetooth Health Profile (HDP).

Bluetooth profile is a wireless interface specification for Bluetooth-based communication between devices. In order to use Bluetooth technology, a device must be compatible with the subset of Bluetooth profiles necessary to use the desired services. A Bluetooth profile resides on top of the Bluetooth Core Specification and (optionally) additional protocols. While the profile may use certain features of the core specification, specific versions of profiles are rarely tied to specific versions of the core specification.

Health Device Profile (HDP) is also a traditional Bluetooth profile. It is designed to facilitate transmission and reception of Medical Device data. The APIs of this layer interact with the lower level Multi-Channel Adaptation Protocol (MCAP layer), but also perform SDP behavior to connect to remote HDP devices. It also makes use of the Device ID Profile (DIP).
### 3.2. Device Specification

![Medical Device Component](image)

**Figure 2. Wearable Monitoring Device Specification**

Figure 2 shows the wearable monitoring device specification. Each component is defined.

**Medical Application** – This component describes the actual medical device application, including its user interface, application behavior, and integration layer to the associated IEEE 11073-20601 stack implementation.

**IEEE 11073-20601 Stack** – This component performs the building, transmission, reception, and parsing of IEEE PDU packets for the associated agent/manager being developed.

**Device Id (DI) Profile** – This component is a Bluetooth profile designed to provide device specific information through use of the Service Discovery Protocol (SDP). If vendor specific information is required as part of a particular Medical Device, this profile provides specific behavior to acquire this information.

**Health Device Profile (HDP)** – This component is the core Bluetooth profile designed to facilitate transmission and reception of Medical Device data.

**SDP** – This component is the Service Discovery Protocol (SDP) used by all Bluetooth profiles to register and/or discover available services on remote devices so that connections over L2CAP can be established.

**Multi-Channel Adaptation Layer (MCAP)** – This component is used by HDP and facilitates the creation of a Communications Link (MCL) for exchanging generic commands, and also one or more Data Links (MDL) to transfer actual Medical Device data.

**Generic Access Profile (GAP)** – This component describes the required features of all core Bluetooth profiles. These features include inquiry, connection, and authentication procedures.

**Logical Link and Adaptation Layer (L2CAP)** – This component supports protocol multiplexing, packet segmentation and reassembly, quality of service, retransmission, and
flow control for the Bluetooth packets transmitted through MCAP.

**Host Controller Interface (HCI)** – This component describes the commands and events that all Bluetooth hardware implementations (controllers) can understand.

**Bluetooth Transport Interface** – This component describes the UART, USB, SDIO, 3-wire, ABCSP, etc. transport interface to the actual Bluetooth hardware components being used. Typically, UART and USB are the most widely used transports.


Continuous health monitoring is essential for recuperating patients and patients with chronic health conditions. It can be used in judging whether an individual is in a physiological state suitable for his duties, and it is also useful for people of all age groups who have possible health problems or have opted for a healthy lifestyle.

![Figure 3. U-Healthcare Monitoring Systems Implementation](image)

The data captured and measured from the wearable monitoring device is further transmitted to the Android smartphone. The Smartphone has developed apps to monitor the data transmitted from the wearable monitoring device. Bluetooth is the connection used to receive the data from the wearable monitoring device. The raw data from the wearable monitoring device is encoded to Android apps. This will be processed and real time monitored in mobile device. There are two main functionality of this system. First, the transmitted raw data from wearable monitoring device is send to the clinical specialist that may require a precise description of the recorded information. This can also be needed in the future diagnosis of the patient health status. Second, the presentation of the health status to the users, there are health status indicator for each vital data (Heart rate, Body temperature). From these data, the user may react for example by following the clinical guidelines or recommendations. The app is automatically connected to the healthcare provider. There is another feature that if the health status is determined to be fatal, the app is automatically directed to emergency call (911) in order to reach an emergency services. Figure 3 depict the u-health monitoring system implementation.
5. Conclusion and Future Works

The existence of growing number of mobile apps in the health domain have been a focus of many studies, however, little contributions have been specifically provided on how to maximize the use of these technology in medical application. This study focused on how to utilize different smartphone apps in u-healthcare system implementation. This study proposes a system u-healthcare monitoring system which is convenient and just in the reach of hand of the users. The integration of wearable monitoring device (IEEE 11073-20601 Stack), Bluetooth and Android Apps are the technologies used in this study. The future works of this study includes the implementation of the storage of medical health information in the cloud.

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