Construction of IoT-based Hybrid App for Patients’ Preventive Management in the Mobile Environment

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Abstract

This study investigated the development of hybrid application for patients’ prevention management and constructed IoT convergence technology capable of providing more customized service to each individual based on the sensing information opening, sharing, spreading and participation which were enabled by the connection between smart devices and the sensor network information that had been used individually in a closed manner.

Also, data collection and establishment was performed on preventive care methods against aspects deeply related to cardio-cerebrovascular diseases such as smoking and drinking as well as healthcare application-related factors including health common sense, etc., to provide more suitable service. It is expected that, in the near future, according to the needs, IoT-related convergence technology will further develop and more research and development efforts will be made to commercialize integrative sensor kit applicable to diverse aspects of real life or individualized sensor products easily interlocked wirelessly.

Keywords: IoT, Smart Device, Sensor Network, HealthCare, Smart Sensor

1. Introduction

Recently along with the development of ICT, society is changing from knowledge and information society to smart society. Smart society is a cutting-edge network base ultra-connection society that is possible to access to information without space-time restriction. The thing that enables this smart society is the internet of things (IoT; Internet of Things)[1]. Internet of things commonly calls the technology which creates future service as smart grid, smart home, health care, intelligent vehicle service, etc. through fusion-complex between IT technology and various industries[1]. Recently, WiFi, LTE and many communication network are advanced. Mobile devices with various sensors and communication modules have become remarkable smaller and functional, receiving attention as a promising future technology to change the industrial paradigm.

With technology development and supply spread of wireless network, communication module and sensor, smart terminal, etc., influence of internet of things is expected to be widely extended from the whole industry to daily life. It is expected to bring innovative change to the existing process and service by being introduced to various fields as medical treatment, traffic, manufacture, circulation, and education, etc.

These days, Internet of Things technology including RFID-based sensor, wearable and mobile devices, has received growing expectation to deeply contribute to resolving the current problems of the healthcare industry and generating more added value. Hospitals have adopted this IoT technology to build smart hospital system to monitor patient-medical staff-equipment locations, movements and specific moves through real-time tracking system; generally manage medical data accesses; and establish Telehealth system including video call, etc.
This paper is structured as follows; Chapter 2 looks at relevant studies and technologies. Chapter 3 is on case study. Chapter 4 shows the proposed system configuration. Chapter 5 constructs the proposed system. Chapter 6 concludes the study and briefly describes future study.

2. Relevant study and Technology

2.1. IoT and Sensor Technology

In early 2013, with the establishment of Ministry of Science, ICT and Future Planning, the attention on sensor-based devices was renewed again. IoT and sensor technology was mentioned as one of the key future search areas along with the significance of network and communication technology that can interlock these sensors [2].

Sensor network technology generally called as USN (Ubiquitous Sensor Network), has been already researched diversely by many research institutes of South Korea. So domestic researchers have multiple technologies [3, 4]. Sensor network technology accounts for a large part of IoT (Internet of Things). By utilizing low-power subminiature sensors, the sensor network technology contributed to environmental variable collection and management from a macroscopic viewpoint that had been unknown to us before.

With the sensor network technology in place, for the past 10 years, we have seen unparalleled smart device innovation. During this revolution, conventional smart devices such as PCs and notebooks came out commercially in diverse different forms to take an important position in our daily lives. Examples of such smart devices include the commonly-used smart phones and smart TVs that have been rapidly spread lately. Recent smart devices have the ability and framework to use own embedded sensors, etc., and make new applied service. Depending upon the convenience of users and developers, these devices can use the embedded sensor values. Such built-in sensors include accelerometer, GPS, proximity sensor and camera, enabling the development of diverse sensor-based applied service.

However, due to the limited size, price and space of smart phone sensors, not all sensors can be built in, thus, it is restricted to satisfy the various needs of users. For this reason, more recently, it is intensely interested and discussed to develop technologies where IoT is connected to use many outside sensors for data collection or control such sensors remotely via own smart devices.

The sensor network technology has been actively utilized in the domestic household appliances sector, in particular. According to the data on domestic sector-specific USN service operation status, in 2007, the service accounted for 9.4% and jumped to 21.4% in 2012, showing a remarkable growth of convergence between smart device and IoT [5].

2.2. Android

Main features of Android are as follows [6];

1) Linux Kernel base
   - Android operates on the OS, Linux Kernel, and is structured under open source principle in every part.

2) Java programming language
   - Java is employed in the mobile sector, which is widely used in the Internet and open source areas, in order for many Java-using developers to easily develop Android applications.
3) Many extended library
   - Android has its own diverse open source libraries necessary for publication development.

Table 1. Features of Android Platform

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Description</th>
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<tr>
<td>Applications</td>
<td>Have key applications such as email client, SMS, calendar, etc.</td>
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<tr>
<td>Application Framework</td>
<td>Provides diverse class and APIs used to develop Android applications.</td>
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<tr>
<td>Android Runtime</td>
<td>Composed of key libraries necessary for runtime and Dalvik VM. Dalvik VM: essence of Android runtime. JAVA VM optimized for the mobile environment. Each Android application is operated as dalvik VM individual instance to run multiple instances in a single mobile device (multitasking supported).</td>
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<tr>
<td>Libraries</td>
<td>Android includes diverse C/C++ libraries including system C library, surface manager, media library, Webkit, SGL, 3D library, Free Type, and SQLite. These libraries are provided to developers through Android application framework.</td>
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<tr>
<td>Linux Kernel</td>
<td>Processes key system services such as security, memory management, process and thread management, network stack, power control and diverse hardware driver (abstracts physical hardware to become accessible in the Android platform)</td>
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3. Case Study

3.1. Overseas examples

3.1.1. U. S. A: The Aventural hospital located in Florida, the US, employed a patient location tracing system for quick and efficient diagnosis of ER outpatients. The hospital brought in AgileTrack, a medical location tracing system developed by GE (General Electric) and built the foundation for comprehensive locational identification of hospital visiting patients and various in-hospital medical devices [7].

    Bracelets with location sensor are provided to hospitalized patients and outpatients so that the medical staff can check patients’ location in real time and more swiftly respond to emergency. The location sensors were also attached onto hospital medical devices to find equipment locations instantly [7].

3.1.2. India: The Manipal Hospital in India provides wearable devices for pregnant women to check their baby status via smart phone and tablet PC app in real time. Data collected through the wearable devices are on important conditions of fetus such as heartbeat and are accessible remotely by responsible doctors [7].

    The hospital also established Central Nursing Stations that monitors patients’ status comprehensively through the wearable devices. Medical staff can access the hospital central information system via smart phone app and read the monitoring information transmitted by the wearable devices. Ideal numbers or data are automatically displayed through appropriate tools to support fast response of medical staff. The system is especially effective in treating chronic diseases requiring continuous health condition check and management [7].
3.1.3. etc.: World major IT enterprises as Cisco, IBM, etc. are establishing related system or suggesting solution to search for new future growth power from the internet of things.12) Cisco has prepared innovation agenda of 'Smart+ Connected Communities' and provides information and service for improvement of quality of life in various fields through ‘Community+Exchange’ solution[8].

Philips has developed smart illumination 'hue' that can control lighting, variously change and adjust color through smart phone app. 'hue' smart illumination can control home illumination automatically or manually through smart phone regardless of place by using WiFi[8].

3.2. Domestic Examples

3.2.1. ElderlyHome Care: In South Korea, the government has implemented ‘U-care Service for the Elderly Living Alone’ as part of its welfare service since 2008. The U-care System for Elderly Living Alone is characterized to provide both safety check service and emergency rescue service for elder people who live alone for their protection [9].

Information from active mass detecting sensor and access detection sensor is analyzed and if activity is not sensed or remarkably lower than usual, managers call or visit them to check their safety. In the event of emergency call or indoor fire or gas leakage detection, nearest fire station is automatically alerted to provide emergency rescue service [9].

3.2.2. Chronic Disease Treatment and Management: Remote patient monitoring system can also be applied to the management of chronic disease patients such as diabetes and cardiac disorders. Most of the products used for remote monitoring of chronic disease patients are approved by corresponding regulatory organizations (FDA, etc.). Product-related converged services are also provided together such as integrative management and analysis solution.

In South Korea, KT, Qualcomm, Korea Center for disease Control and Prevention and the Gyeonggi-do government have jointly performed Q-care, a pilot project of diabetes and blood pressure management. Examples of IoT application to chronic cardiac disease patients are Corventis’PiiX, and AliveCor’s ECG meter, etc.[10].

In chronic disease management, regular drug administration is also essential together with continued biometric data measurement. Here, the IoT is utilized.

3.2.3. Health-On Service: In March, 2013, SKT and Seoul National University Hospital started "Health-on" service, the world's first individual customized health management program service. Health-on is possible to analyze and consult health condition by providing realtime data such as quantity of movement and size of meal, etc., through activity quantity measuring instrument put on the wrist or the waist, ‘Activity Tracker’, through smart phone [11].

4. Proposed System Design

4.1. Diagram on System Composition

The application developed in this study is based on Java language and run on Dalvik. Dalvik is Virtual Machine produced by Google and operated in the top area of Linux Kernel. The mobile device-optimized MySQL-based SQLite database is used to build the basic data necessary for each item directly in devices. Information is collected and managed depending upon users’ usage. In addition to this, the proposed system supports 2D and 3D graphics, medial GSM technology, Bluetooth, GPS, etc., and uses pulse sensor open source project to sense heartbeat.
The proposed smart phone application herein requires OS version higher than a certain level and smart phone library supporting preventive management function. Also, to design the optimized user interface for user implementation on smart phones, Android-provided resources should be utilized. And to measure heartbeat automatically with device, external sensors are necessary based on Arduino, etc.
5. System Building

5.1. Android Hybrid App Development

Smart phone application interface was constructed based on Android SDK 2.2 version. Each interface designed by level unit is consisted of Android activity. Also, in order for users to effectively cooperate through smart phone GUI, user convenience was considered to the maximum extent in Android resource arrangement in the interface.

Suitable service for the research purpose was provided by collecting and building data on items appropriate for healthcare application such as health common sense as well as preventive measures against items deeply related to cardio-cerebrovascular diseases such as smoking and drinking.

The service was designed to simply present the information then give quiz for users to review important points in each item and naturally practice and prevent in their real life.

A hybrid app development is aimed in this study, which runs on Google Android platform environment. First, page layout is done in XML in line with the story board; JAVA commands are structured to connect the result; generate JDK and register with the Google Android market.

![Figure 3. Preventive Care HybridApp](image)

5.2. Heartbeat Measurement and Management by using External Sensors

Heartbeat measuring sensor is developed herein, which is external sensor device capable of interacting with the application developed based on Arduino, an open source-based single board microcontroller. In the Arduino integrated development environment, heartbeat measurement software is developed by using Pulse sensor, an open source project, and Pulse sensor kit hardware while uploading the executable code at the same time.

![Figure 4. Arduino Uno R3 SMD Edition](image)
The measurement data of sensors based on node.js are sent to Android native app via the short-range wireless technology of Bluetooth. The data are saved in user heartbeat measurement database. By referring to the pre-saved user health-related information, the system uses the measurement data to show the results and current health conditions. And also utilizing the continuously accumulated data, the app provides helpful information regularly on future cardio-cerebrovascular health management and prevention.

Figure 5. Pulse Sensor Kit Configuration

6. Conclusions

This study has investigated so far the development of hybrid application for cardio-cerebrovascular disease prevention and IoT convergence technology capable of providing more customized service to each individual based on the sensed information opening, sharing, spreading and participation which were enabled by the connection between smart devices and the sensor network information that had been used individually in a closed manner.

In the study, a hybrid app was constructed through Android application. Although it was developed in Java, the app can be migrated or applied to multiple commercial smart devices such as iOS and Window phone platform by diverse multiplatform engines.

In step with the rising user demand, various smart devices such as smart phones and smart TVs are moving out of the existing method of using embedded sensors to embrace IoT and use/control external sensors as if they were inside themselves as a single unit. They are changing to a new paradigm of more communion with human. In this situation, more relevant research and service development will be made.

Given the still limited sensing capacity of smart devices, external sensors are often relied upon. But, more recently-released smart devices seem to embrace more active technological and product changes, responding to market demand by embedding heartbeat sensor in itself in some cases.

In the near future, IoT-related convergence technology is expected to grow further in line with such demand and such technology will be applied to real life in diversified aspects such as versatile integrative sensor kit or individualized sensor products with easy wireless interlock.

References

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