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Design of Wearable Bio-patch System Platform in Human Healthcare Environment

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Abstract

The process structure of wearable bio-patch information system is organized by the sequence stages from a patch user to background information system through mobile network environment. These information processes show complex and various data formats in wearable bio-patch computing systems. Thus, we need to systemize data structure in viewpoint of bio-information cycle system. In addition, the design of wearable patch platform is required to support continuous research and development of wearable patch systems. Finally, we propose the basic data set and the evaluation functions, which make various bio-information patterns management efficiently.

Keywords: Bio-information Structure, Digital Patch, Human Healthcare, Wearable Platform Design

1. Introduction

We are recently interesting in wearable electric bio-devices and bio-patches as a future IT-convergence solution. The need of wearable devices and wearable-patch systems is gradually increased because they can support user healthcare and mobile environment-care with lightweight mobility[1–3].

This work cultivates the computing platform and information interaction about wearable bio-patch integrated package. It has also present bio-information collection method and bio-data structure of user through wearable-patch based bio-sensing module. Figure 1 shows an example of wearable bio-patch information system. It shows the process of gathering bio-information for the wearable-patch user as a form available at healthcare and recuperation facilities.

The wearable-patch system gathers the bio sensing information of each individual patient through a personal-type bio-sensing device. For gathering the bio-information, it can use wire networks such as LAN and PSTN or wireless networks such as WIFI, Zigbee and Bluetooth. Then, it can transmit the collected bio-information using an interworked network through wire IP network or wireless 3G/4G global network. Also, the role of monitoring and managing the bio-information of each user has been performed through PC or bio-information server located at the protected infrastructure network[4–6]. The sensing information collected from various wearable-patch devices can configure different information processing systems depending on the sensing method, transmission channel, storing and filtering conditions as well as analysis and evaluation method, etc[7,8].

The following sequences describe the bio-signal information processing components based on wearable-patch devices. Firstly, they configure the bio-data gathering process of bio-information device users. It can define the gathering method of the bio signal data such as blood pressure level and blood pressure distribution of users along with the related data format. It defines the method of gathering the respiration bio-signal data and the related data format. It defines the method of gathering

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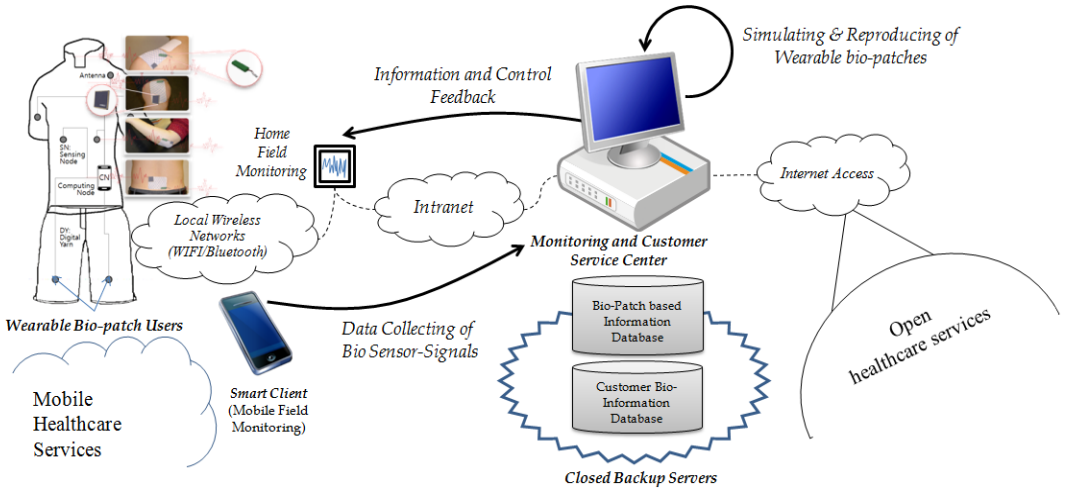

Figure 1. Wearable Patch based Bio-information Systems.

the user physical analysis data and the data format. The definition of user posture, movement, location model and pattern should be provided. It includes the user identification information of bio-information device and the user authentication processes.

Secondly, they configure the processes to save, analyze and evaluate the user's health condition and the related bio-signal data. It can present a user bio-information signal based on the health condition model for each user. It presents a user bio-information signal based user health condition model. In this paper, for modeling of health condition, we define the threshold value function and the classified values to classify satisfactory/warning/danger, etc. The health condition management process of bio-sensing devices should be defined for each user. We define the identification information and the status information for the digital patch system management. The statistical analysis and evaluation model for analyzing and evaluating the individual user should be defined.

Thirdly, they can configure the information guide process and the control process for wearable-patch device users. We can design the information display interface for showing health analysis information of a user. It can show the outbreak of danger and the warning signals on the specific user. It can display of real-time health information analysis, display of respiration and health related signals, and display of physical status analysis information. In addition, it can setup a bio-information device using learning statistics model of each individual user.

Finally, they can define the wearable-patch device system and wearable system convergence development process. The definition of information table and process on the bio-patch device development support is needed. It presents the definition and guide on the important convergence points.

The structure and components of such wearable-patch system closely interact with the bio-information sensing cycle described in next chapter. The digital patch bio-information cycle standard model should be proposed and continuously enhanced more and more. A bio-information execution environment for bio-patch sensing process is provided. More specially, the data structure for patch bio-information systems is required for more systemized data managements.

This paper consists of the following chapters. Section 2 reviews the previous studies relevant to wearable healthcare system and bio-path data structure. Section 3 and 4 presents the wearable patch computing platforms including patch-device platform, bio-information processing platform, and user-support platform. Finally, Section 5 describes the conclusions of this work.

2. Data Structure in Electric Bio-patch Information Cycle

With the advent of wearable computing technologies, many different studies about the wearable healthcare service technologies have been explored for ensuring the provision of healthcare service for patients at home, at work or on the move without having to see doctors directly in person[9,10]. Wearable bio-patch healthcare service technology involves more advanced models than the

wearable healthcare service drawing attention recently, where patients can receive medical results via the healthcare service system based on bio-data collected by a range of medical sensors and devices in living space[2,3]. As a rule, the wearable healthcare service technology is used for on-going monitoring in daily routines of high-risk groups including pregnant women and patients with chronic diseases and cardiac disorders to determine and predict diseases proactively as part of emergency services. Given the presence of diverse services involving wearable-healthcare information, system authority, efficiency and security issues are considered important[11,12]. This is a highly sensitive part such as heart beat in view of patients' life and safety, in which sense the assessment of security and stability is of great importance.

Body condition is associated with an individual's psychological state and the related cognitive function can control the physiological state. Skin electrical activity may be an indicator to detect action of the nervous system. Nerve terminal stimulates sweat glands by controlling the physiological activity. This stimulation leads to changes in the conductivity of the skin and is sensed by a physical sensor. To finalize the signal chain of bio-patches and of adjusting bio-patch solution, we consider what the signal conditioning impact on the overall power efficiency calculations. The sample rate of ADC from the sensor response of a typical ECG signal can be optimized. If the sample rate is reducing, the ON time of solution become minimized, and the overall power efficiency of the system can be improved. Bio-patch sensing data is sent to the wireless gateway, the gateway can be self-monitoring and remote monitoring of professionals. Bio-patch sensing data is sent to the wireless gateway, the gateway can be self-monitoring and remote monitoring of professionals. Further, because the bio-patch form-factor can be more closely in contact with skin than other wearable solutions, this is possible much more accurate data acquisition.

Bio-patch solutions as a wearable-sensor support monitoring continuously or semi-continuously the physiological and cognitive parameters of the patient or athlete without connecting to a wired hub network. The wearable bio-patch process gathers the various bio-information of a patient using piezoelectric sensor, respiration sensor, etc. The gathered bio-information can be sampled or transformed as various digital bio-information such as peak information, amplification information, location information or body type information, etc[4,5]. This can feedback with the backward control process for controlling and guiding the bio-information devices and the bio-information patients such as the clinical trial, or it can

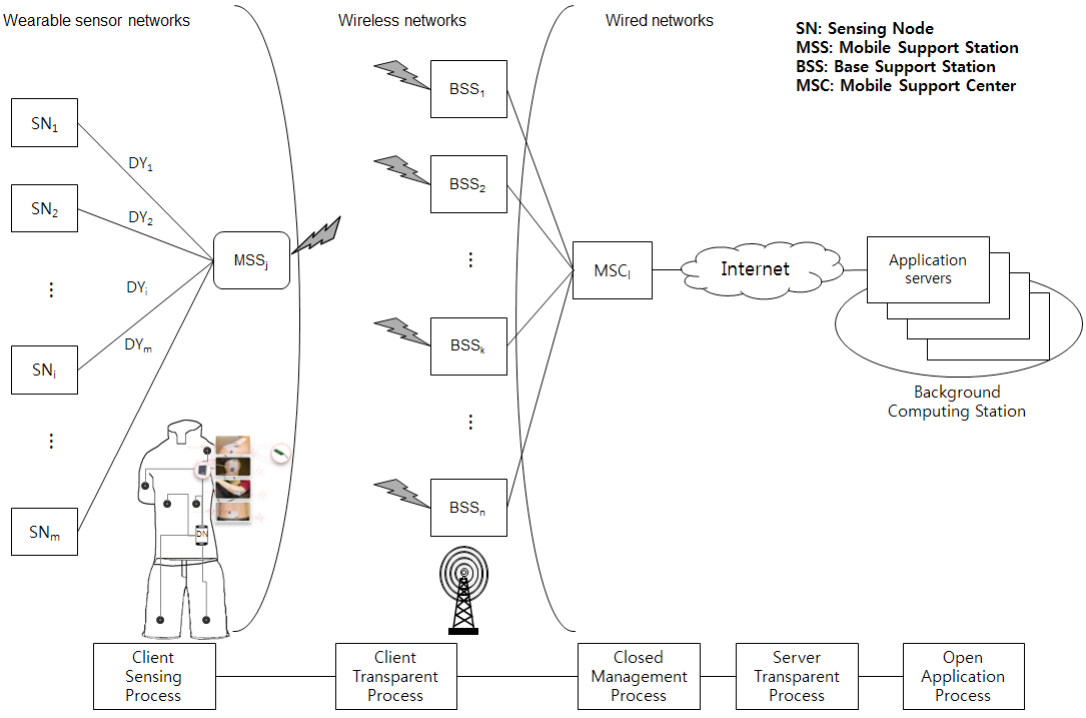

Figure 2. Bio-information Sensing Network Systems and Cycle.

support analyzing, evaluating and controlling through gathered health information.

The data format of bio-information transmitted here may be the analog signal or digital conversion code as raw data. Otherwise, the filtered source bio-information has the characteristics of specific peak data, specific interval data or specific event data[1]. The consistent data structure should support the systemized data format as well as various data types. It can represent a digitalized signal ON-OFF state with one bit(1/0), and the different signal states with leveled values of several bits (2-bit, 3-bit, 4-bit, and etc). We also should represent a meaningful periodic data format in accordance with time variance. Moreover, we should represent a-periodic data format for representing a significant events.

The sensing information process of bio-information system is composed of raw sensing, data transforming, data filtering, data transmitting, data saving, data analyzing and statistical-zing of the sensing device as shown in Figure 2.

Figure 2 shows the overall sensor network process of wearable-patch bio-information system. Such bio-patch process may be executed after being dynamically selected depending on the system configuration environment. The selecting method of dynamic processes can be classified as horizontal process and vertical process[4,5].

Firstly, the horizontal processes are selectively operating the station by each stage depending on the necessity of applied environment. For an example, the wearable bio-information system collected from the wearable biosensors within a personal wireless network performs the process of skipping a static station by selecting the third mobile station. In other case of the wire based bio information system, the third mobile station process may be skipped. As another example, the elimination of processes at the last open station becomes required in order to perform an exclusive intranet service. As another example, the instance of connecting a local wireless network at the third mobile station selects the fourth local station while the instance of connecting a wireless wide area network performs the process as the fifth global station after skipping the fourth local station. The count of process steps may be increased or decreased depending on user's requirements and system environments. If the number of steps is increased, the data redundancy and system access point may be increased. However, the system reliability and availability can be increased, and system applicability can be enlarged. If the steps are increased, it is more difficult to ensure the synchronization and security of system. Secondly, the vertical processes are optionally selecting or deselecting some computing processes at the stations of specific stage. For example, the instance of performing digital conversion at the sensing station can disable the digital conversation executions at the follow-up stations, such as the mobile station, local station and global station. Then the sensing data gathered at the first sensing device is transferred so that the data filtering process can be performed selectively from the second sensing station to the last open station depending on the usage environments.

This study proposes a wearable bio-patch process cycle design and execution method as an application model. The collection process of sensing signal data based on digital bio-patch has been designed considering the following points. It is based on the distribution status of biomaterial, the acquisition method of bio-signal data, and the data format definition. The acquisition method and data format of user's bio-signal data should be defined. Then, the data acquisition method and data format based on the model analysis of wearable bio-patch are defined.

The model of patch size and shape is defined. This includes a process definition about the identification information and authentication of patch user. We can design the user status and bio-signal data store, analysis, and evaluation process. This presents user's medical condition model based on bio-signal. The threshold functions and the evaluation values are defined to separate good/boundary/risk/etc. Thus, this definition is applied to the state management process of the external environmental conditions such as the temperature, biomaterials, etc. The identification system and status information management for using external environmental parameters is defined. This defines the statistical analysis and evaluation model of bio-information for each individual user.

3. Wearable-patch Computing Platform

The integrated operating platform is required for managing all components including wearable patch module, computing module, patch user interfacing module, etc. As shown in Figure 3, the wearable patch platform is composed of patch-device platform, bio-information processing platform, user-support platform, etc. This wearable computing platform system presents a consis-

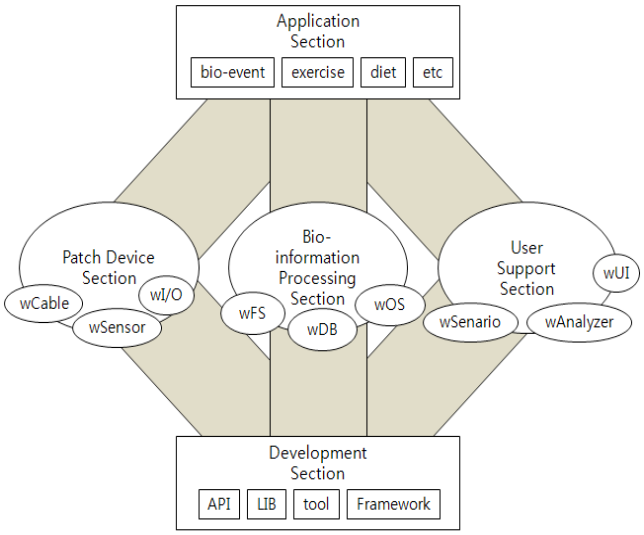

Figure 3. Configuration of Wearable Bio-patch Computing Platform.

tent view about data collecting and delivering in planning, design, development, testing, management, etc. of an electronic-patch system.

3.1 Patch-device Platform

First, the patch-device platform has been consisted of storage and memory, network, server/PC, wearable-sensing devices, wearable-IO devices, etc. for wearable-patch information services. In addition, an extended hardware platform can support the general smart devices such as smart phone and smart pad. The wearable-patch wire and interface provides the standardized wearable-wire to support bio-information transmission of wearable-patch. It supports embedded wire as well as transmission cable. It can provide wearable embedded connector and interfaces for supporting extension and connection between various wearable-patches and related embedded devices (digital cable and interfaces).

Wearable sensors (w-Sensor) can configure the platform that compatibly integrate and operate the fabric sensor or ultra-light embedded sensors. It supports the bio-information sensing or the external environmental sensing for users. Wearable I/O provides input-output data formats, communication protocols, and more for supporting the information output-input of the wearable computing. It supports the standard and standard-compatible methods in various wearable input-output devices.

3.2 Bio-information Processing Platform

Second, the bio-patch information processing platform has organized with wearable-OS (wOS), wearable-FS (file system), device drivers, networking protocols, wearable-DBMS, etc. for wearable-patch computing services.

In order to operate information systems based on digital clothing, the wearable-OS (wOS) builds a memory-based file system (wFS, Non-FS) and supports the distribution protocols via the various transmission paths. It can strengthen the ultra-light resource and user management. Wearable-DBMS (wDBMS) consists of a formal set of data inside the digital clothing, and builds a database system to support interworking and compatibility with external data sets.

3.3 User-support Platform

Third, the user-support platform provides various models and tools for investigating user requirements, and for designing user interfaces and user scenarios. The user's selection functions as requirements analysis tool enable to present the application selection list of the users, and accordingly to constitute a functional selection list of digital clothing. The design model and tools of user scenario support to design the user's application scenarios of digital clothing over time in periodically or aperiodically. User Interface model shows the user interface configuration, or proposes the conveniently applicable standard model. Your application provides a variety of basic application. Additionally, the user data model should establish the type and class of user information, information format configuration, the information transmission/storing medium, information processing method (or tools), etc.

Digital clothing user requires the development of a various interface device and interface method. Voice input device receives the user's voice as input, and supports user authentication, data input, interfacing, and more. Speaker/earphone output device conveys sound information to the user. Visual input device, for identifying the status information of the user, provides appropriate visual information processing services to a user by receiving the camera view. For example, the user's environment control, the user security guard services, and more are provided with.

Specifically, the virtualization-based the wearable virtualization can be achieved. Wearable virtualization can remove dependencies between the digital clothing and

the corresponding computing system, and can maximize the system flexibility and scalability.

3.4 Wearable Development Platform

For developers, a development platform can be configured to support the compiler, editor, design tools, development tools such as development library, API, frameworks. Wearable APIs is to support the open programming interface (Open-API) to develop applications for digital clothing. Compiler and editor organize a dedicated compiler and provide digital clothing system-based program editing capabilities. Wearable framework supports an integrated wearable system development environment including digital garment design, program editing, compiling, and etc.

3.5 Application Platform

The application services are provided such as user motion guides, diet guides, etc. by supporting the program selection of bio-information application. It can support the accuracy of the health information that the user wants by supporting search service of the bio-information. It can provide the health simulation services of individual user. It is required to enter the basis biological information for healthcare of users.

Specially, the application platform can support the applicable services, which dynamically select the reasonable application, and services according to user's requirement specifications.

4. Bio-information Evaluation on Basic Data Set

We will define the called "basic data set" that is a signal pattern on a period when bio-information of human-body represents the similar signal patterns periodically. At a real-time environment, bio-information can show different signal patterns against the basic data set. Although, the bio-signal patterns may have the regular signal patterns within the range value of error tolerance. The error tolerance values can be coordinated according to the external environment characteristics of application fields such as health state, expert opinion, etc. The function of basic data set would be defined by S(x). The function of error tolerance values would be set by the range of (x). The range of (x) can be accepted from maximum S(x) + (x) to minimum S(x) - (x).

Figure 4 shows the relations of evaluation functions on a basic data set. The "S(x)" is a basic data set that includes bio-information of human body. The basic set, S(x), is a set of sequential bio-data collected from normal states. The "x" is a sampling sequence in the reference period, and "F(x)" is the data values evaluated in the evaluation section of the current cycle, "(x)" is the tolerance error rate. The function "F(x)" is represented by the following expression.

$$F(x) = S(x) \quad (1)$$

$$F(x) = S(x) - (x) \quad (2)$$

$$F(x) = S(x) + (x) \quad (3)$$

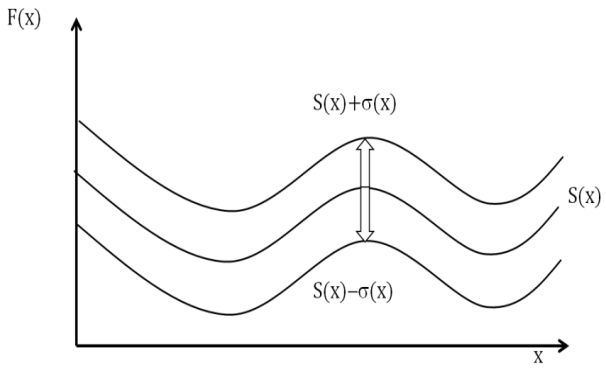

Figure 4. Evaluation Functions on Basic Data Set.

In the actual application environment, the biological information "F(x)" is collected in real-time. When the evaluation value of "F(x)" satisfies the condition of equation (2) and equation (3), it shows that the physical condition of a bio-information user is normal health state. If the evaluated value of the current period is out of the above range, we can record the sequence number of sampling period, the sampling location, the error difference value with the alarm event because it is outside of the allowable error range. The error values out of the allowable range generate an alarm event.

5. Conclusion

This paper has proposed a bio-patch cycle design and wearable bio-patch platform in order to reduce the system complexity followed by the various component configu-

ration of bio-information system. This has showed the basic bio-information sensing cycle configuration and the bio-sensing platforms. Such wearable bio-sensing cycle and platform configuration carries an advantage of supporting the adaptability followed by change of various healthcare system environments such as user environment, bio-information gathering type and method, etc. without the invalid or unnecessary system configuration of wearable computing resources. The wearable bio-patch cycle had shown the bio-information flow based on bio-information system architecture.

In addition, this study describes the wearable patch platform for continuous research and development of digital patch systems. Platform can be an important means, which accumulate system configuration and development.

The proposed evaluations are possible to evaluate the health condition of the users. When the unit period becomes enlarge, a basic data set becomes enlarge and evaluation time becomes enlarged. When the unit period be reduced, basic data set be reduced and evaluation time becomes short. When the unit period becomes enlarge above a certain size, enlarge error rate. When the unit period is reduced under a certain size, an error representation set rapidly become enlarge.

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