Wearable Passive biosensing interface method for gathering bioinformation

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***Abstract*— Recently, a variety of biometric information systems have been tried and developed to provide IoT-based healthcare and medical information services. Existing biometric information systems actively collect and analyze biometric information around user terminals or smart devices. On the contrary, this study proposes a passive biosensing system and a passive sensing method for collecting and analyzing biometric information using wearable passive patches. In particular, a passive sensing system and method using a passive patch that can be detected by activation of an external power source without an internal battery is proposed. This paper focuses on the following elements of passive biometric information system. The first describes the structure and components of a passive patch system that can be operated from an external source without an internal battery. The second describes passive biometric information algorithms that passively detect biometric information in real time. Finally, we propose a passive sensing analysis modeling that analyzes and evaluates the signal sensitivity of biometric information, and describes an analysis example of bioinformation sensitivity.**

***Keyword*—Passive sensing, Patch interface, IoT, Wearable system, Bioinformation**

I. INTRODUCTION

WITH the development of various wearable systems, the methods for monitoring a human body, analyzing a bio-signal, evaluating a health condition of a user, and providing a healthcare service based on the evaluation have been continuously attempted. These efforts have had some fruitful consequences, and have become a future vision strategy that is important for the healthcare sector. This paper describes a sensing system and a sensing method based on bio-information collection interface using passive patches. Especially, it is a research on sensing system and sensing method based on information gathering interface using passive patch which can be sensed by the activation of external power without internal battery [1].

When a drug is administered to treat a patient, it is largely divided into oral administration and parenteral administration. In this case, the parenteral administration may be divided into mucosal administration methods such as ocular mucosal administration, nasal administration, sublingual administration and rectal administration, and injection administration methods such as intravenous injection and subcutaneous injection, and skin administration method [2-6]. Among them, the method of administering the drug through the skin is as shown in Fig. 1, using a paste, a patch, or a wetting agent.

Until now, digital patches have been used as means and methods for collecting human body information. These efforts contributed to the collection of various biometric information such as body temperature, sweat, humidity, respiration, pulse, and heart rate. Nevertheless, the types of sensors available for patching are limited and the amount of information that can be collected is limited. These attempts should continue to develop new sensors, patch structures, and bio-signal analysis.

This paper considers the following issues in order to realize a passive patch system that maximizes applicability. First, there is a need for an alternative to overcome the mobile support and user convenience constraints of a typical power built-in active sensing patch. Next, a power supply alternative is needed with a no-power biometric information system configuration for semi-permanent product and service configuration. Finally, by providing a consumable patch sensing module according to the no-power patch system configuration, the patch production cost is minimized to maximize the applicability.

The subjects of this study are as follows [7]. The first is to provide an organization of a passive patch system based on an bioinformation gathering interface that can operate with external power without an internal battery. The second is to provide a passive patch based on an information collection interface that can sense the degree of action of the applied drug and display it to the patient or the user. The third is to provide a passive patch based on an information gathering interface that can inform the user or the patient when the degree of pharmacological action is out of the threshold and can lead the user or the patient to remove the patch attached. Finally, this study is to provide a sensing system and a sensing method using a passive patch based on an information collection interface capable of acquiring biometric information and providing it to an external network.

This study aims to classify and define biometric information sensing method in systematically developing and implementing biometric information sensing and biometric information system [8] [9] [10].

Manuscript received on June 21, 2019. This work is a follow-up the invited journal to the accepted & presented paper of the 20th International Conference on Advanced Communication Technology (ICACT2018), and Grant ID is 2020001.

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First, there is an *active bio-sensing method* for sensing and collecting biometric information of a target object in accordance with its own bio-logic execution while continuously supplying power and electric power to the sensing module.

Second, the sensing module can be configured with passive sensing logic without its own built-in power or without external power supply. In order to sense and collect biometric information of a target object, a sensing module is transferred to a wireless local power and activation (or synchronization) signal, and necessary biometric information is sensed through a sensing circuit and a wireless transmission circuit module that are passively operated It is a *passive bio-sensing method* to collect.

This study applies passive bio-sensing method without built-in power in the patch module as bio-information sensing module and system configuration method. The main issues to build processes and systems for collecting, storing, and processing biometric information are as follows. An active agent and a wireless interworking interface configuration for activating the passive sensing module are needed. In particular, consider how to design the signal activation, the available frequency band and the signal strength. As a layered structure of the passive sensing module, process support such as activation signal reception, individual bio-information sensing, biometric information transmission and power signal amplification are important issues. Finally, the real-time signal analysis capability of the active agent and the non-real-time bio-information application data model of the background server are recognized as major issues.

The application fields of biometric information technology and system of this study are as follows. Currently, it is active in the medical and healthcare fields that utilize mobile platforms such as smart phones and smart clocks [11]. It has been steadily expanding in the fields of sports and clothing [12], beauty sector [13], agricultural biology sector [14], automobile and transportation sector [15] and security certification sector [16].

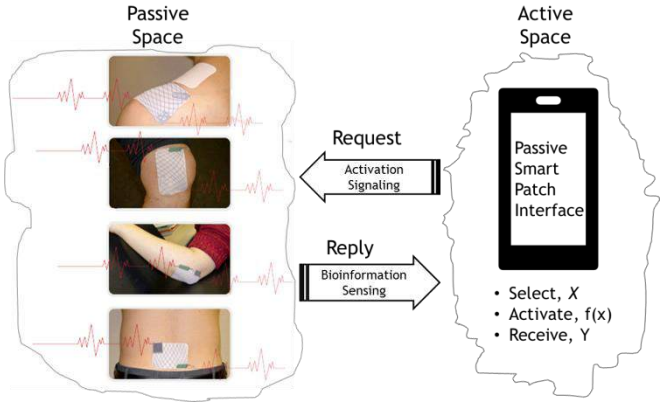


Fig. 1. A Computing Domain Configuration for Wearable Passive Patch Bioinformation System

This study has the following contributions [7]. The passive patch based on the proposed biometric information collection interface can operate with external power without built-in battery, it is easy to miniaturize, shorten manufacturing process time, and reduce production cost. And, such a passive patch can measure the degree of action of the drug and induce removal of the patch when out of the threshold range. Additionally, it can transmit the biometric information of the patient to the outside and transmit the action information of the internal medicine of the patch used for the treatment to the outside, so that the transmitted data can be easily browsed. Accordingly, the patient, the caregiver or physician can conveniently check the patient status, and can transmit a patch removal message or the like when the medicinal threshold of the passive patch attached for the patient treatment is out of the range. Finally, the sensing system using the passive patch based on the proposed bio-information collecting interface receives the biometric information transmitted from the passive patch and transmits the biometric information to the registered communication terminal when the biometric information is out of the threshold range.

II. Architecture Of Passive Sensing System

A. Component and functions

In this study, a passive patch attached to a patient and measuring the biometric information signal of a patient and transmitting it to the outside, and an active terminal connected to the passive patch, transmits an activation signal to the passive patch, and receives the biometric information signal as shown in Fig. 2 [7]. This passive patch constitutes an information collecting interface based passive patch sensing system characterized in that external power is temporarily supplied without operation of an internal battery.

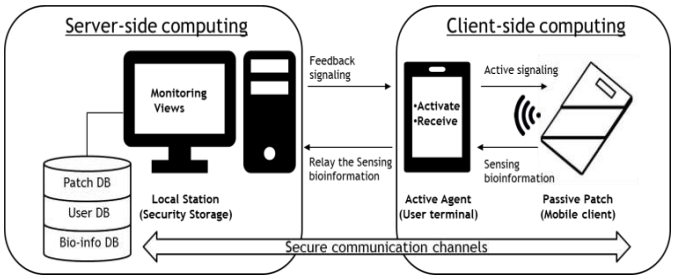


Fig. 2. The Wearable Bioinformation Computing System with a Passive Patch Interface

In addition, the expansion system may further include an external server connected to the active terminal in a wireless or wired manner, and the external server may include a passive information collection interface-based patch sensing system capable of receiving a biometric information signal of a patient from an active terminal acting as a mobile agent.

Here, as shown in Fig. 3, the passive patch constitutes several layers of partial modules from the bottom to the top as follows. The first lower layer constitutes the drug application layer on which the drug is formed on the lower surface which is in close contact with the skin of the patient. The second layer is a supporting module formed on the upper part of the lower drug coating layer, and includes a biosensor module for measuring a biometric information signal of a patient and a drug action detection sensor module for generating a drug action signal by measuring the degree of the drug acting on the patient do. And a power supply module for operating the built-in circuit by receiving power from the outside. The third layer includes a display module formed on the upper part and

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a control module for generating a patch removal inducing signal corresponding to the drug operation signal when the drug action signal is out of a predetermined threshold value range and transmitting the signal to the display module.

The sensing data transmission structure of the passive patch system is as follows. First, the active terminal performs an activation process to send an activation signal to the passive patch attached to the patient. Second, a passive patch that transmits an activation signal from the active terminal proceeds with a biological information sensing step of sensing drug and human body information. Third, the passive patch consists of a feedback step of feeding the sensed drug and human body information to the active terminal. Finally, the active terminal constructs a storage process for storing the sensed drug and human body information in the internal memory. At this time, the passive patch can be operated by temporarily supplying external power without an internal battery.

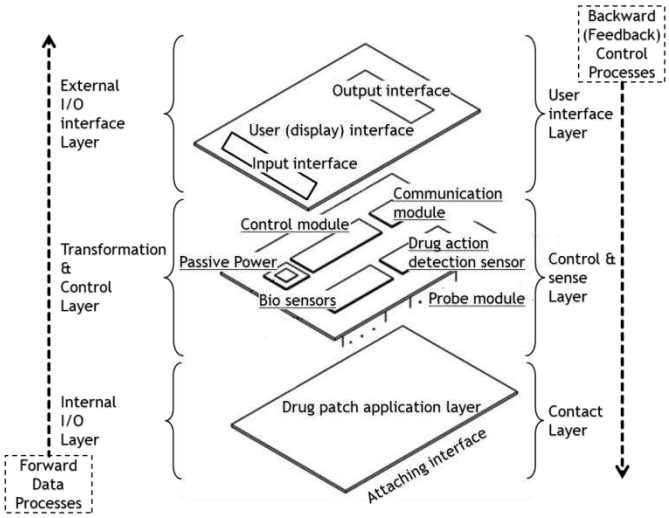


Fig. 3. The Layered Architecture and Components of Passive Patch on the Client-side

Further, the drug information and the human body information stored in the active terminal can be further expanded to an external transfer process for transferring and storing the drug and the human body information to a database of the external server.

B. Data and control flows

Data flow from data collection to data analysis and evaluation service of bio-information sensing system is shown in Fig. 4.

The data flow of the passive biometric information system starts data input and sensing at the passive object by the activation signal of the active agent.

Then, data processing such as data conversion, data transmission and storage based on data compression, real-time data pattern and semantic analysis, non-real-time background data analysis, and data generation of biometric information application services are performed.

The passive-based sensing data flow mainly collects a small amount of data on the smart agent on a non-periodic basis, and provides a real-time alarm and a status notification service of the biometric information to the user or the terminal according to the occurrence of the event.

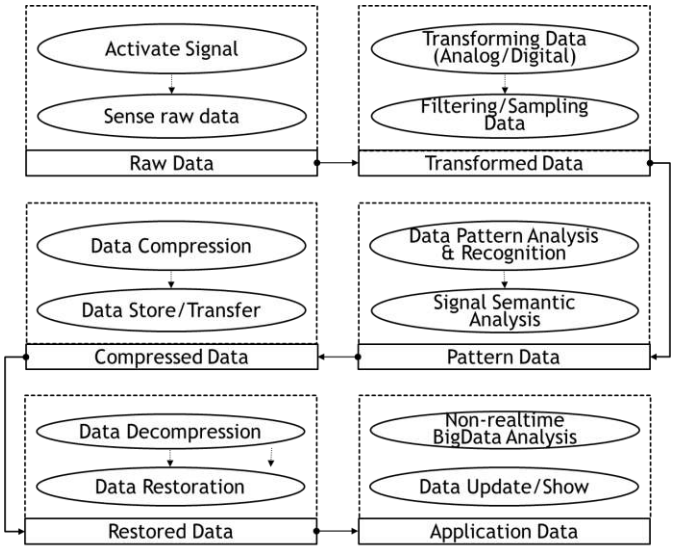


Fig. 4. Data Flow Processes on Bioinformation System

In addition, the information collected in the smart agent terminal is transmitted to a PC or a server located in the background, continuously analyzed and evaluated, and updates various bio-information.

III. Algorithm For Passive Sensing Processes

The detailed components for implementing the passive patch biometric information system include a drug action detection sensing module, a biosensor module, a power supply module, a control module, a communication module, and a display module as follows.

The drug action detection sensing module can detect the drug application layer, or the concentration of the drug detected in the skin of the patient. Further, the drug action detection sensing module may generate a drug action signal through the detected signal and transmit the drug action signal to the control module. Here, the drug action detection sensing module may be formed through at least one probe to contact the drug application layer or the skin of the patient.

The biosensor module can measure a bio-information signal including at least one of body temperature, pulse, blood sugar, skin humidity, electrocardiogram signal, and brain wave. In addition, since the biometric information signal measured according to the attachment position of the passive patch differs, the bio-sensing module can select a different type of sensor depending on the attachment position.

The power supply module may be formed to be able to receive power temporarily from the outside. To this end, the power supply module may configure a USB terminal or configure an electric wire or a pin to receive external power. At this time, the power supply module may be connected to the built-in circuit formed in the control module. That is, the power supply module can receive the power temporarily from the outside to operate the built-in circuit, whereby the passive patch can be operated. Meanwhile, the power supply module may receive power wirelessly. At this time, the wireless power supply may be an electromagnetic induction type, the power supply module may constitute a primary coil, and electromagnetic can be guided through a wireless supply device having a secondary coil to supply power to an internal

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circuit.

The control module may receive the drug action signal input from the drug action detection sensing module and compare the received drug action signal with a pre-set threshold value. Also, the control module may generate a patch removal inducing signal and display the patch removal inducing signal on the display module when the value included in the drug action signal is out of the threshold value range. For example, if the concentration of the drug contained in the received drug action signal is lower than the threshold value, the control module can generate a notification that the patient can remove the passive patch, that is, a patch removal inducing signal because the drug treatment effect is low. In addition, the control module can generate a patch removal inducing signal so that the patient removes the passive patch because the drug may cause side effects when the concentration of the drug contained in the received drug action signal is higher than the threshold value.

The communication module may transmit a biometric information signal or a patch removal inducing signal or a drug action signal to the outside of the passive patch. Further, the communication module may include wireless communication means capable of communicating at a short distance, such as Bluetooth. For example, the communication module can transmit a biometric information signal or a patch removal inducing signal or a pharmacological action signal to a nearby electronic communication terminal (for example, a smart phone) in a Bluetooth manner. At this time, the communication module may use a module to which the ZigBee communication method or the NFC (Near Field Communication) communication method other than the blue pitching method is applied.

The display module may be formed on the upper surface to display a signal informing of the removal of the patch. The display module also receives the patch removal induction signal and displays the set colour or message to inform the patient or user of the patch removal.

As described above, the passive patch described in this study can be powered by external power supply without built-in battery.

In addition, biometric information of the patient can be transmitted to the outside, and action information of the internal medicine of the patch used for the treatment can be transmitted to the outside, so that the transmitted data can be easily browsed. In this study, an active terminal as an agent terminal can use a WIFI or Bluetooth network or the like, and thus can connect to an external server using such a communication network.

In addition, the active terminal and the external server can store the subscribed patient information. At this time, the patient information may be stored through one of the active terminal or the external server and shared with each other. In other words, when stored in the active terminal, the stored information is transmitted to the external server and stored in the external server, transferred from the external server to the active terminal upon storage, and transmitted to the active terminal.

Here, the reference health information may be reference health information classified according to the patient's age, sex, body shape or the like or pre-set reference health information (for example, blood pressure, pulse, blood glucose level, etc.).

This standard health information can be used by backing up the data stored in the existing hospital database for the recent health condition information and medical history information. If necessary, the patient can receive the data from the treated hospitals and store it on the active terminal or the external server is.

This is an extended feature of the sensing system using the passive patch based on the information gathering interface so that it is possible to manage the health and medical information according to each user, thereby enabling more efficient additional service support.

The proposed passive biometric information sensing system is divided into two parts. One is the passive patch portion of Fig. 5, and the other is the mobile active agent portion shown in Fig. 6. The sensing module of the passive patch waits for the activation signal from the mobile active agent, and the mobile active agent transmits the activation signal to the passive patch whenever biometric information collection is required. The details of each process are shown below.

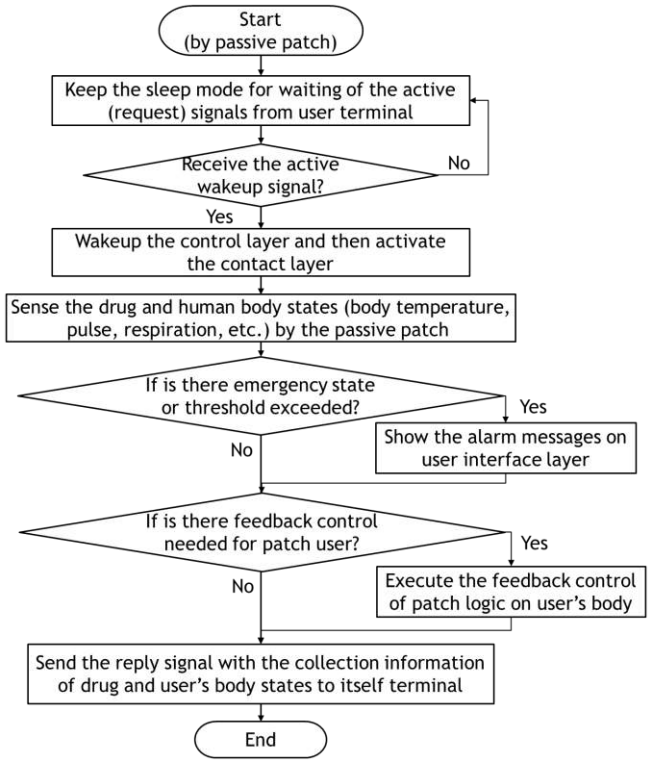


Fig. 5. The Embedded Logic Sequences of Passive Patch

Fig. 5 is a flow chart showing a passive sensing method using passive patches based on the bio-information collection interface. The bio-sensing process using the passive patch is as follows. First, a process in which the active terminal of a client transmits an activation signal to a passive patch attached to the patient. Then, a passive patch that receives an activation signal from an active terminal and wakeups itself senses drug or human body bio-information such as body temperature, pulse, respiration, etc. At this time, if the bio-sensing information exceeds the threshold or an emergency occurs, the alert message is notified to the patch display interface. Third, a reply process returns the sensed drug and human body information to the active terminal. At

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this time, feedback control can be performed on the passive patch if necessary. Finally, the active terminal carries out a process of receiving the sensed drug and the human body information, and storing it therein.

Fig. 6 shows the processes of collecting sensing information received from a user mobile terminal and transmitting information to an external server as a mobile agent.

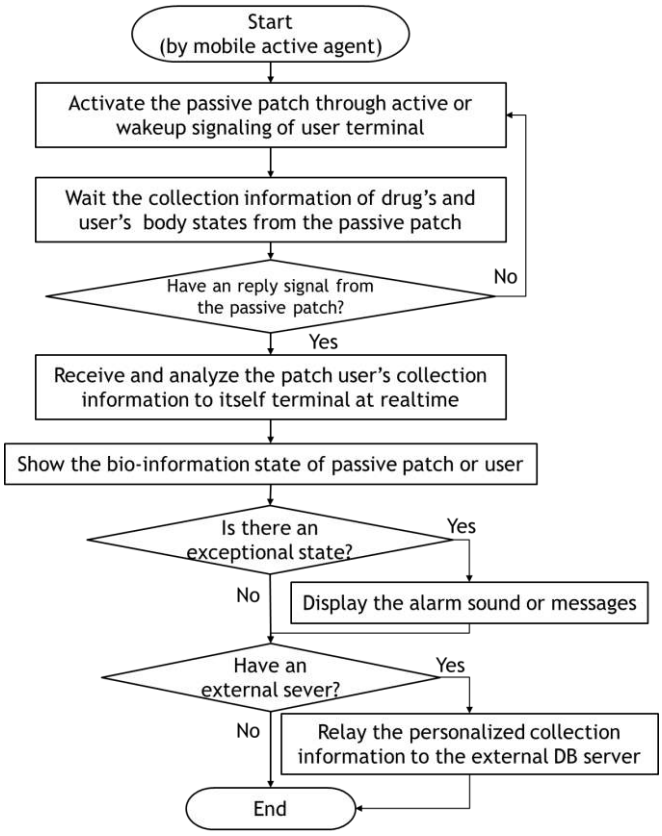


Fig. 6. The Active Agent Logic Sequences of Mobile Terminal

In Fig. 6, the user terminal initially activates the passive patch with an active signal. Next, it waits for receiving the bioinformation and the user's biometric information from the passive patch. If a reply message is detected, it stores the received bio-information in its storage space, and displays the bio-information state of passive patch at real-time. Then, if there is an exceptional state, it can show the alarm services on the mobile terminal. Finally, when the external DB server is existed and interconnected, the information collected through the external communication channel can be relayed and constructed as a database.

IV. ANALYSIS MODEL OF PASSIVE SENSING

This study first proposed a passive bioinformatics system. And, this configuration can be a good alternative to overcome the power consumption limitation of the digital patch. In addition, the cost of producing a digital patch is minimized, thereby maximizing the economic efficiency of the product. Ultimately, we will expect the availability of passive digital patches to vary.

A. Experimental environments

Passive RFID systems use tags with no internal power source and instead are powered by the electromagnetic energy transmitted from an RFID reader. The wireless communication configuration of the passive sensing data transmission system for passive patch sensing is as follows.

As the name implies, passive tags wait for a signal from an RFID reader. The reader sends energy to an antenna which converts that energy into an RF wave that is sent into the read zone. Once the tag is read within the read zone, the RFID tag's internal antenna draws in energy from the RF waves. The energy moves from the tag's antenna to the IC and powers the chip which generates a signal back to the RF system. This is called backscatter. The backscatter, or change in the electromagnetic or RF wave, is detected by the reader (with the antenna), which interprets the information.

Combining sensor monitoring with RFID allows for the observation of uniquely identifiable items at short and long ranges. Whether using battery power or collected RF energy, sensors can collect relevant data pertaining to temperature, humidity, moisture, and motion/movement of human body. With advancements in technology, especially in energy collection and impedance, sensor monitoring can now be accomplished using passive RFID tags without a decrease in read range. Recently, manufacturers have figured out a way to incorporate sensors into passive RFID tags without greatly affecting read range. Because passive tags do not have an internal battery to power the sensors, passive tags use RF energy to power the IC/sensor and to send the relevant information back to the reader. Currently, passive RFID sensor tags can be used to detect body states such as temperature and humidity or moisture because of a newly wearable integrated circuit (IC). The IC is designed with a bank of capacitors that is able to detect the presence of moisture based on how the moisture affects the tuning of the antenna. That information is then backscattered back to the RFID reader for observation.

RFID systems, readers and tags communicate mostly through the method of electromagnetic coupling. In order for an RFID tag to communicate with an RFID reader/antenna, the tag circuit and reader circuit generally must couple in some way. Coupling is a transfer of energy between two electronic items or two circuits. For example, systems that use capacitive coupling use electric currents instead of the magnetic field in order to couple. Contact to a few centimetres of read range is normal for (LF) or Low Frequency communication because of the need to produce an electric field using electrodes.

Passive RFID tags do not all operate at the same frequency. There are three main frequencies within which passive RFID tags operate. The frequency range, along with other factors, strongly determines the read range, attachment materials, and application options.

As the first frequency model, Low Frequency (LF, 125~ 134 KHz) has an extremely long wavelength with usually a short read range of about 1~10 centimetres. This frequency is typically used with animal tracking because it is not affected much by water or metal.

The second frequency model with High Frequency (HF, 13.56MHz) & Near-Field Communication (NFC) has a medium wavelength with a typical read range of about 1 centimetre up to 1 meter. This frequency is used with data transmissions, access control applications, DVD kiosks, and

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passport security – applications that do not require a long read range.

The third model with Ultra High Frequency (UHF, 865~960 MHz) has a short, high-energy wavelength of about a one meter which translates to long read range. Passive UHF tags can be read from an average distance of about 5 – 6 meters, but larger UHF tags can achieve up to 30+ meters of read range in ideal conditions. This frequency is typically used with race timing, IT asset tracking, file tracking, and laundry management as all these applications typically need more than a meter of read range.

As a general rule, higher frequencies will have shorter, higher-energy wavelengths and, in turn, longer read ranges. Moreover, the higher the frequency, generally speaking, the more issues an RFID system will have around non-RFID-friendly materials like water and metal.

B. Analysis and evaluation Model

This study starts by collecting human body and patch application data based on a sensing patch module by constructing a human - based wearable patch.

The factors affecting the wearable sensing system are sensing sensitivity and sensing success rate, sensing data rate, power consumption, production and component cost, sensing scalability, mobility, lightweightness, and many other environmental variables.

Nevertheless, this study focuses primarily on the sensing sensitivity and the ability to transmit sensing data as the main environmental variables for analysing and evaluating the performance of passive sensing patches.

Let us assume that the power transmitted by the reader has a uniform power density in all directions over a spherical surface at any given distance *d*. Some of this power is received by the tag antenna and is proportional to the effective aperture of the tag antenna and the power impinging on the tag [17].

In RFID, the distance between the reader and passive tag has a very significant effect on the power loss which decreases as the inverse square of the distance between the reader and passive tag. The power density received at a distance *d* is given by the free space transmission formula,

$$P_d = \frac{P_r}{4\pi d^2}$$

where P_d is the received power density, P_r is the power radiated by the reader antenna and *d* is the distance between the reader and passive tag.

First, the sensing sensitivity represents the reception sensitivity for each radius according to power and active signal strength as shown in Fig. 7.

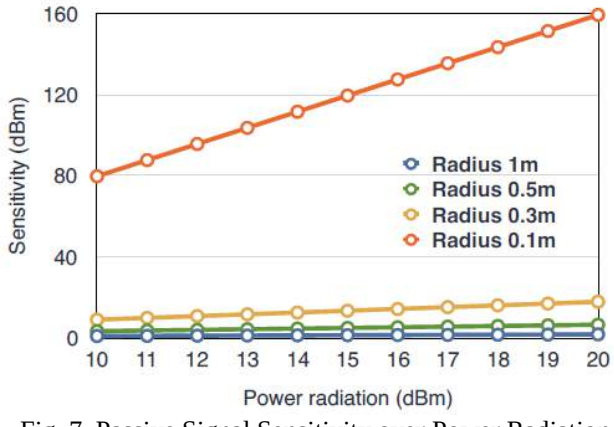


Fig. 7. Passive Signal Sensitivity over Power Radiation

Second, the receiving sensitivity is expressed according to changing in transmitter power of the received signal versus the signal transmission distance between the active terminal and the passive patch as shown in Fig. 8.

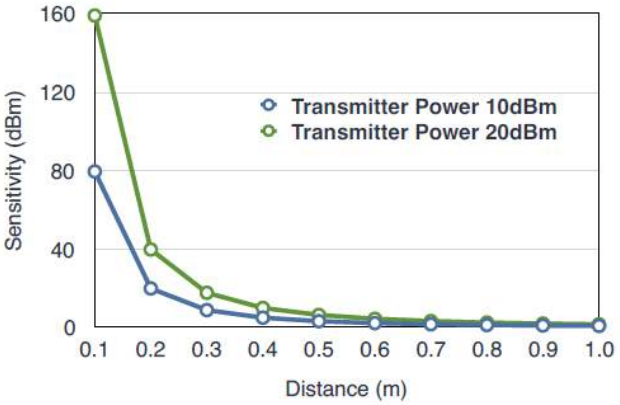


Fig. 8. Receiving Signal Sensitivity over Distances

V. CONCLUSION

In this paper, we first proposed the architecture and components of passive biometric information system. This proposed system can be a good alternative to overcome the limitation of power consumption of digital patches. In addition, the cost of manufacturing a digital patch is minimized, maximizing the economic efficiency of the product and maximizing market usability.

Then we proposed biometric information collection and feedback algorithms, proposed an analytical model of passive sensing system, and described analysis evaluation examples. This suggests a future direction for the design of advanced biometric information system.

In the future, this study intends to expand the scope of research by constructing multi passive patch biometric information system. We intend to build an embedded bio-sensing platform for the development of embedded bio-sensing PCB / Chip.

REFERENCES

[1] T. G. Lee and S. H. Lee, "Dynamic Bio-sensing Process Design in Mobile Wellness Information System for Smart Healthcare s", *Wireless Personal Communications*, Vol. 86, No. 1, p. 201-215, 2016.

[2] P. Celka, R. Vetter, P. Renevey, C. Verjus, V. Neuman, J. Luprano, J. D. Decotignie and C. Piguet, "Wearable biosensing: signal processing and communication architectures issues", *Journal of Telecommunications and Information Technology*, p. 90-104, 2005.

[3] T. G. Lee and S. H. Lee, "Design of Wearable Bio-patch System Platform in Human Healthcare Environment", *Indian Journal of Science and Technology*, Vol. 8, p. 1-7, 2015.

[4] S. Patel, H. Park, P. Bonato, L. Chan and M. Rodgers, "A review of wearable sensors and systems with application in rehabilitation", *Journal of NeuroEngineering and Rehabilitation*, Vol. 9, No. 21, 2012.

[5] T. G. Lee, M. S. Ko and S. H. Lee, "Wearable Multiple Bio-sensing Process Architecture in Human Healthcare Environments", *International Journal of Bio-Science and Bio-Technology*, Vol. 6, No. 5, p. 177-184, 2014.

[6] Tae-Gyu Lee, *Chapter 15. Mobile Healthcare Computing in the Cloud, Mobile Networks and Cloud Computing Convergence for Progressive Services and Applications*, IGI Global, p. 275-294, 2014.

[7] T. Lee, "Sensing system and sensing method of passive patch interface for gathering bioinformation," The 20th International Conference on Advanced Communication Technology (ICACT), Chuncheon-si Gangwon-do, Korea (South), 2018, pp. 652-655. doi: 10.23919/ICACT.2018.8323869

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[8] Ki-hwan Chon and Hyung-jin Choi, "A Study on Ubiquitous Psychological State Recognition Model Using Bio-Signals," The Journal of Korean Institute of Communications and Information Sciences, Vol. 35, No. 2, pp. 232~243, 2010.
[9] Jin Seob Shin, Woo Young Ahn and Il Yong Oh, "Development of Diagnosis System through Human-body Information Measurement," Journal of the Korea Society of Computer and Information , Vol. 13, No. 1, pp. 219~226, 2008.
[10] Jee Hyun Lee, Eun Ji Lee, Ji Eun Kim, Yoo Lee Kim and Sin Won Cho, "Wearable Sensing Device Design for Biological Monitoring," Journal of the Korean Society of Costume, Vol. 65, No. 1, pp. 118~135, 2015.
[11] Ju-Hyun Choi, Seung-Man Chun, Dong-Hyun Jang and Jong-Tae Park, "Design and Implementation of Bio-data Monitering System Based on ISO/IEEE 11073 DIM/REST for IoT Healthcare Service," Journal of the Institute of Electronics and Information Engineers, Vol. 52, No. 3, pp. 3~12, 2015.
[12] Tae-Gyu Lee, Gi-Soo Chung and Seong-Hoon Lee, "Textile IT Convergence: Digital Clothing and Wearable Computing Status," Korea Institute of Information Technology Magazine, Vol. 10, No. 2, pp. 77~86, 2012.
[13] Eun Hye Park and Seung Jin Moon, "U-Healthcare offers and designed wired and wireless integrated Hair care System," Proceedings of Symposium of the Korean Institute of communications and Information Sciences, pp. 698~699, 2010.
[14] Y. S. Kwon, "Greenhouse environmental management by phytomonitoring," Protected Horticulture and Plant Factory, Vol. 8, No. 1, pp. 127~130, 1995.
[15] Tae-hwan Park, Hwa-joeng Seo, Ji-hwan Lim and Ho-won Kim, "Suggestion of Secure Driver Authentication and Vehicle Control System based on NFC Communication and Biometric Information," Journal of the Korea Institute of Information and Communication Engineering, Vol. 22, No. 4, pp. 700~707, 2018.
[16] Myung Geun Chun and Ki-young Moon, "Use of biometric information and protection of privacy," REVIEW OF KIISC, Vol. 15, No. 6, pp. 11~18, 2005.
[17] R. B. Green, “The general theory of antenna scattering,” in Ph.D. Thesis, The Ohio State University, Columbus, OH, 1989.



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