Design of Mobile Monitoring Service based on Internet of Things Utilizing Characteristics of Ethylene

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Abstract Background/Objectives: ***In a mobile environment, the monitoring system should be designed in consideration of the characteristics of light-weight devices. In this paper, we have come up with the view that it is necessary to promote rational consumption by actively providing freshness status to consumers by utilizing plant hormone characteristics.***

Methods/Statistical analysis: ***This paper aims to provide information on the freshness of the space where the vegetables are stored by utilizing the characteristics of plant hormones so that consumers can confirm information using mobile. Therefore, we design the structure of the monitoring service system which relates to android based mobile device.***

Findings: ***This paper also describes the implementation of server and client to provide freshness notification function to monitor the amount of ethylene gas to inform the mobile device. The proposed method estimates the freshness of ethylene and the consumer can eat the fruit and vegetables in the refrigerator during the period when the ethylene reaction is not shown as such as possible, rather than removing ethylene gas like existing products and provide the result to the consumer's mobile device.***

Improvements/Applications: ***The proposed system architecture applies the service-based mobile application. Some of the functions that the user needs are distributed on the server side and the system is monitored using the client application installed on the mobile device.***

Keywords: Mobile environment, Internet of Things, Monitoring system, Freshness, Service-based mobile, Android-based mobile

I. INTRODUCTION

The Plant growth requires water, light energy, carbon dioxide, inorganic salts, and other special chemicals in the body, which are called plant hormones. Plant hormones, like hormones in the human body, have only a very small effect on the plant and are produced in the plant itself as needed. There are many kinds of plant hormones, among which the hormones related to the growth of plants are called growth hormones[1]. In many researches, they have been made to control the freshness of fruit and vegetable plants through the properties of plant hormones, however they have not been widely used. Plants and growth and development are very common phenomena that we encounter every day, but we cannot see much use of them in life[1].

Many of the agricultural products begin to release ethylene gas after harvest. Ethylene gas is one of the plant hormones that promote fruit ripening and aging of plants. Ethylene gas promotes aging and decay of fruit, causing it to fester or decay. Conventional ethylene sorbent is a product that helps to store and store fruits and vegetables for a long time by adsorbing and removing ethylene gas which promotes the aging of plants[2]. It has been known that certain gases can mature fruit. Grocker and Knight reported that the constituent of the smoke was ethylene, and Cousins reported that they should not put the orange and banana together on the boat because some substance released from the orange prematurely bananas. Denny says that ethylene, which is produced when burning kerosene, is also involved in the mating of bananas and citrus, and Gane has discovered that this gas, which causes fruit maturity, is ethylene that is synthesized in plants[2, 3].Plasma care is a process in which the purifying agent generated in the plasma reacts with ethylene gas to reduce it back to water and carbon dioxide. Among these, carbon dioxide is measured in a very small amount in a concentration of ppm. Most of existing products using ethylene have been used to adsorb or decompose ethylene gas and to reduce ethylene to maintain the freshness of agricultural products. In addition, most of the products have not yet been popularized by consumers because they release products that can maintain and preserve the freshness of agricultural products from the perspective of producers rather than consumers[3]. Therefore, we design a monitoring service system that predicts the freshness of the horseradish perennials by monitoring the ethylene, and provides them to the consumers in order to widely utilize the characteristics of ethylene.

The remote control and monitoring services based on Internet of things (IoT) are being developed in various types. Table 1 below shows the types of Internet based remote control and monitoring services[4, 5]

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Table 1: Types of remote control and monitoring service based on IoT

Type of service	Service example	Explanation
Industrial management	Industrial refrigerator	Manage the operational status of industrial equipment or machinery
Environmental management	Smart palm	Management of indoor environment such as temperature and humidity
Medical care	Remote healthcare	Patient health information or status management
Security management	Intelligent CCTV	Managing life safety or security status

These types of services can be used to monitor devices to identify situations and to remotely control when problems arise, saving manpower, time, and costs. Table 2 analyzes the requirements for each type remote control and monitoring service based on IoT[6].

Table 2: Requirements for type of service

Type of service	Power efficiency	Security strength	Operation speed
Industrial management	low	low	slow
Environmental management	low	usually	slow
Medical care	high	high	usually
Security management	usually	high	speed

For example, power efficiency is not the efficiency of the power used to freeze items in a refrigerator, but the efficiency of power to enhance security, such as encryption. This is very important if you carry it like a medical management type. The security management type requires a lot of cases when it is necessary to operate with an emergency battery even when the power is disconnected due to an unexpected situation.

Mobile devices such as smart phones are limited in terms of resources such as computing power, memory, screen size, and battery life due to their small size. Therefore, complicated functional applications are cumbersome to install and operate on mobile devices[7, 8]. To overcome these shortcomings and to maximize the use of mobile devices, service-based mobile applications are attracting attention[9].The service-based mobile application is installed and operated on the service side by implementing many functions of the service, and the client application installed on the mobile device calls and uses the service. By executing the target application at the two nodes in this way, the problem of the resource constraint of the mobile device can be solved[10, 11].

We mainly use the method to remove the plant hormone ethylene syringes. However, depending on the fruit and vegetables, the temperature and the ethylene synthesis rate are different, and the ethylene reaction is inevitable even when inhibited. Therefore, we propose a mobile monitoring service system consisting of android application and web server for freshness status of fruits and vegetables. Most of the existing researches using ethylene have absorbed or decomposed ethylene gas and used a method of decreasing ethylene to maintain the freshness of agricultural products. Also, most commercialized products maintain and preserve the freshness of agricultural products from the producers' point of view and have not been widely available to consumers. Therefore, in this paper, the user provides user-based monitoring by managing the freshness through the monitoring of ethylene.

II. REAL-TIME MONITORING OF FRESHNESS AND DESIGN OF MOBILE ALERTS

Agricultural products such as fruits and vegetables are naturally secreted by ethylene, such as growth hormone, after harvest. Ethylene gas from the fruit ages the fresh sorghum and lowers the lead. In this paper, the freshness notification function is provided to monitor the ethylene gas amount and inform the mobile device of the amount of ethylene gas so that it can be eaten when freshly cooked vegetables are placed in the vegetable compartment the refrigerator. As shown in Table 3, the method proposed in this study is different from the conventional method in that the ethylene gas is removed as in the case of the conventional products, since the ethylene reaction for temperature and ethylene synthesis rate varies depending on the fruit and vegetables, estimate freshness by measuring ethylene so that consumers can eat veggies in refrigerator. The goal of this research is to provide the results to consumers' mobile devices and help them to eat fresh fruits and vegetables within a reasonable time.

Table 3: Initial Set of features used for the experimentation

Fruit vegetables	Ethylene synthesis rate	Temperature (°C)	Ethylene reaction
Watermelon	0.1 ~ 1.0	200	very sensitive
Cucumber	0.1 ~ 1.0	20	very sensitive (softening, yellowing, decay)
Eggplant	0.1 ~ 0.7	12.5	sensitivity (increased corruption)
Tomato	4.3 ~ 4.9	20	sensitivity (confusion, softening)
Apple	2 ~ 4	0	promotes aging, low hardness, spot
Banana	0.3 ~ 10	20	promotes coloration

2.1.Operation of freshness monitoring system

In this paper, we design a monitoring system that guides users to smartphone terminals by monitoring the real - time ethylene synthesis rate which threatens the freshness of the horseradish.

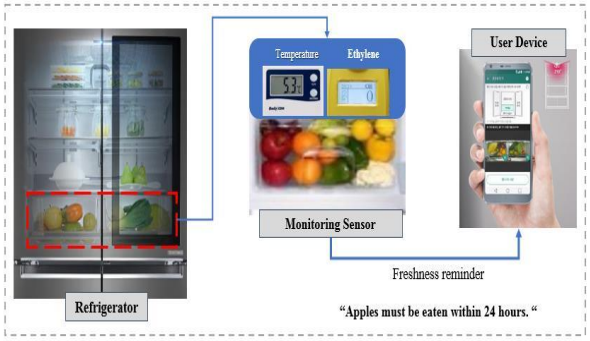

Figure 1. Monitoring and notification system

In Figure 1, the cabinet of the refrigerator is equipped with a temperature sensor to measure the temperature and an ethylene sensor to measure the ethylene synthesis rate. The temperature sensor part collects the temperature data using the sensor module in the refrigerator and the ethylene sensor part measures the ethylene synthesis rate in real time according to the age of the fermentation. According to the synthesis rate of the ethylene reaction stored in the database, the user is notified of the freshness in real time on the mobile device.

2.2.*Structure of mobile monitoring system*

The system architecture proposed in this paper adopts service based mobile application structure. Mobile information delivery systems are essential for modern people. Currently, almost all information is transmitted through mobile devices and a lot of information is being collected and consumed. In this system, some of the functions required by the user are stored in the refrigerator server side, and the system is designed to execute the entire functions through interaction with the user application installed in the mobile device through the wireless network. The structure of the proposed system is shown in Figure 2.

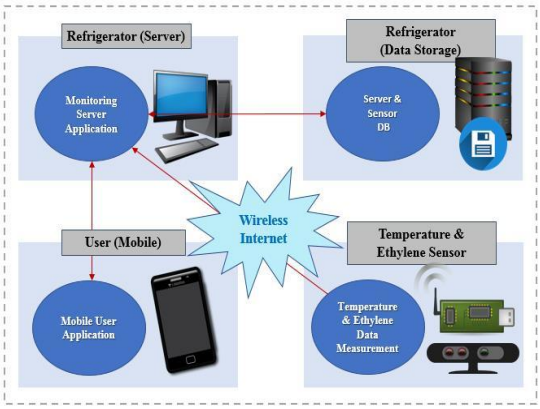

Figure 2. Structure of proposed monitoring system

The temperature and the ethylene sensor part collect and transmit temperature and ethylene synthesis rate data using the center module in the refrigerator in Figure 2. Temperature and ethylene sensors measure values in real time. The application (refrigerator) section manages the whole application program and receives the measured data and provides the analyzed value to the user in real time. The user part of the mobile phone can check the current temperature and the ethylene data value through the application service. The user can check the freshness information received from the server through the mobile phone and eat the freshly vegetables in a fresh period. The mobile part can be used in various ways to suit your needs. For example, it is possible to provide a sequence of fruits and vegetables to be consumed as a result of the freshness prediction, and a variety of utilization schemes can be provided by providing a recipe for cooking that can be utilized in this order.

III. MONITORING SERVICE

A real-time mobile monitoring system is assumed to design the proposed system. As shown in Table 3, the ethylene content in the refrigerator is monitored in real time because the optimum temperature and the ethylene synthesis rate are different depending on the types of fruits and vegetables such as watermelons, branches, and apples. For example, monitor the user to be able to eat fruit by notifying the user immediately before the ethylene synthesis rate at 0°C is in the range of 2 to 4, to ensure the freshness of apples. We designed server and client to implement this function. The server acts as a kind of information provider, and the client acts as a user. In order to show the application example, we implemented a monitoring interface that connects Java and Android.

3.1.Server Design

The interface of the server should take into account the sensor data elements that occur in the refrigerator sensor. As shown in Figure 3, when the sensor senses temperature and ethylene synthesis rate, the monitoring server utilizes the temperature and ethylene information received from the sensor. The data of the ethylene synthesis rate of each fruit and vegetables stored in the data store are compared and analyzed and the results are transmitted to the client side.

Figure 3. Real-time mobile monitoring server-side operation method

The user interface for managing the server can set the information currently being monitored and confirm the information received from the sensor. The received data is processed through the server through the classification process and then stored in the database. The monitoring screen showing the current freshness of the refrigerator confirms the temperature and the ethylene synthesis rate. The monitoring interface shows the current freshness of the refrigerator using real-time information input

from the sensor.

Application server for monitoring service is implemented in Java. Sensors that specify ethylene data measure ethylene synthesis rates in real time. In addition, the monitoring server transmits the analysis result to the client side using the ethylene information received from the sensor.

Figure 4. Operation of android application

In this paper, we design a web server that is interworked with existing wireless network for network-based ethylene monitoring. The measurement data collected from the mobile devices connected to the network is sent to the web server through the android application. The measured data transmitted from the mobile device can be stored in the web database which can be inquired by the web server and interlocked. Figure 4 shows the data transfer process. It is possible to transfer data both in the forward direction from the android application to the web server, from the web server to the DB.

In the user interface for server management, it is possible to set the current monitoring information and to check the pure packet information received from the center. The received packet data is processed in the working memory through the server using the classification process and then stored in the database. On the screen that shows the current state of monitoring, user can check the information on the ethylene. The monitoring interface displays the current screen using real-time information input from the sensor. If a risk factor is detected in the freshness monitoring, the information is output to the monitoring screen through a status notification alarm and a message as shown in Figure 5.

3.2.Client Design

The mobile phone client is implemented on android-based. The user can check the current state of the wireless network and receive a mobile monitoring service if it operates normally. If the network of mobile device cannot be used at present, the service cannot be provided smoothly. In the android applications, network access is required to use external services. The measured ethylene data is also stored in SQLite inside the user's mobile device. The GUI is implemented so that the stored DB data can be confirmed by the graph function and the tables in the view function. It is designed to be able to inquire the details of each measurement data by adding a menu button on the GUI. The application of the user device has the function of transmitting the web server so that the measurement data can be sent to the server connected to the Wi-Fi network and the DB can be stored and monitored. This is done using a Java socket. In order to receive mobile service by using socket communication, the first thing a user needs to do is to select a monitoring server or check the network status. The user checks the current network status and receives normal mobile monitoring service. The screen connecting to the user monitoring server operates the server for smooth operation of the monitoring service.

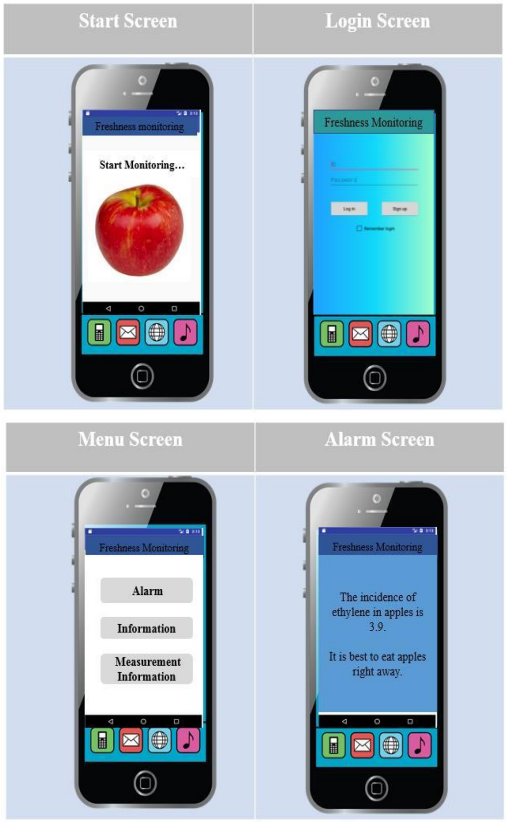

Figure 5. Client screen

When the user accesses the monitoring web, the screen activates the monitoring service. If a freshness alarm occurs on the monitoring server, a warning message appears on the user's mobile interface with a warning message.

Figure 5 shows the screen when the application is run. This is the initial execution screen. If you touch the screen, it moves to login screen. When login is completed, information is provided according to the selection menu. The menu consists of three main screens as shown in Figure 5. First, it is a notification function according to the freshness measurement result of the refrigerator. The alarm menu is configured to provide notification information according to preset or preset values of freshness. This alarm function is automatically displayed when information is generated even though it is not selected. This feature enables active information provision to consumers. In addition, the Information menu provides specific information such as nutrition, freshness and storage period for fruits and vegetables stored in the refrigerator.

3.3.Information management service

The ethylene monitoring service is a service for detecting the condition of the refrigerator, and it shows the data of the temperature and the ethylene synthesis rate to the user.

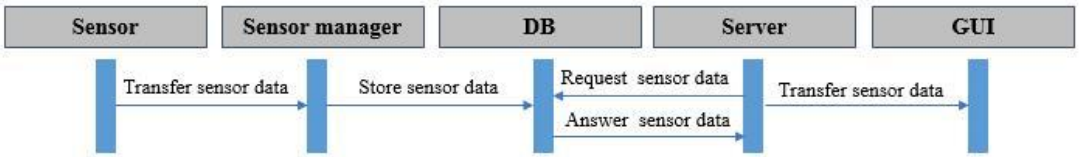

Figure 6. Process for monitoring service

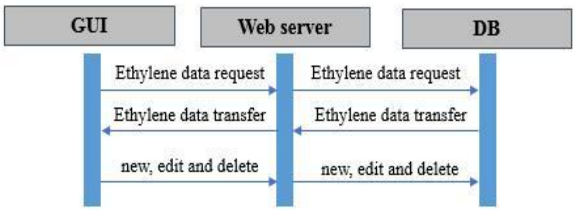

Figure 7. Process for information service

The detailed operation of the monitoring service is shown in Figure 6. The temperature and ethylene synthesis rates from the temperature and ethylene sensors installed in the refrigerator are measured and sent periodically to the sensor manager. The sensor manager receives the packet data, extracts the value of the new sensor, converts the data to each unit, reads the information of the fruits and vegetables stored in the database, and transmits the information to the user's GUI. The user can monitor refrigerator temperature and ethylene synthesis rate with the information received. The information management service is a service to easily add, modify and delete information about fruits and vegetables stored in the database through the user GUI. Figure 7 shows the operation of the information management service. When the user requests fruit and vegetable information using the user GUI, the server transmits the information stored in the database to the user.

IV. CONCLUSION

This paper designed a system to monitor the freshness of refrigerator in real time by measuring the ethylene in the refrigerator and using mobile device. The proposed system is designed by applying service-based mobile application and it can be applied in industry considering the freshness of refrigerator from the viewpoint of the user. In this paper, we measured and forecasted freshness through ethylene monitoring of refrigerator and proactively provide this information to users. To show the application example of the proposed system, we implemented a monitoring interface that connects Java and Android. To manufacture this monitoring system, it is necessary to study not only the hardware such as electronic and mechanical fields such as the development of cheap and precise ethylene sensor to be attached to the refrigerator but also the software field which can improve the utilization of the consumer.

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REFERENCES

1. A. J. Hamilton, G. W. Lycett, D. Grierson. Antisense gene that inhibits synthesis of the hormone ethylene in transgenic plants. Nature. 1990 Jul;346(1):284-7.
2. Joseph J. Kieber, Joseph R. Ecker. Ethylene gas: it's not just for ripening anymore!. Trends in Genetics. 1993 Oct;9(10):356-62.
3. Roberto Solano, Joseph R. Ecker. Ethylene gas: perception, signaling and response. Current Opinion in Plant Biology. 1998 Oct;1(5):393-8.
4. Y. A. Ahn. Context awareness inference engine for location based applications. Proceedings of International Conference on Convergence and Hybrid Information Technology; 2010. pp. 25-34.
5. Y. A. Ahn. Design of rule-based inference engine for the monitoring of harmful environments in workplace. Journal of the Korea Industrial Information Systems Research. 2009;14(4):65-74.
6. R. Sukanesh, S. PalanivelRajan, S. vijayprasath, N.S. Aishwarya, P. Gracy Angela. Intelligent wireless mobile patient monitoring system. Communication Control and Computing Technologies 2010 IEEE International Conference; 2010. pp 540-3.
7. YanniZhai, Xiaodong Cheng. Design of smart home remote monitoring system based on embedded system. 2011 IEEE 2nd International Conference on Computing, Control and Industrial Engineering; 2011. pp. 41-4.
8. T. Fukatsu, M. Hirafuji. Field Monitoring using Sensor-nodes with a web server. Journal of Robotics and Mechatronics. 2005;17(2):164-172.
9. Xiaobo Mao, Keqiang Li, Zhiqiang Zhang, Jing Liang. Design and implementation of a new smart home control system based on internet of things. 2017 International Smart Cities Conference; 2017. pp. 1-5.
10. Ala Al-Fuqaha, Mohsen Guizani, Mehdi Mohammadi, M. Aledjari, M. Ayyash. Internet of things: a survey on enabling technologies, protocols, and applications. IEEE Communications Surveys & Tutorials. 2015 Jun;17(4):2347-76.
11. Rajeev Piyare. Internet of things: ubiquitous home control and monitoring system using android based smart phone. International Journal of Internet of Things. 2013;2(1):5-11.