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Design of ICT-based Agricultural Safety Monitoring System Models

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Objective: This study carried out base research to build an agricultural safety monitoring system through ICT convergence to reduce safety accidents and enhance welfare in life in the agricultural field.

Background: The functions and values of rural villages as the space of living are recognized anew, but occupational accident rate due to farm work accidents is on the rise each year. Therefore, the seriousness of such a problem emerges. The convergence technology combining ICT is recently applied to industries overall, and therefore better services are offered. However, studies on ICT convergence has not yet been applied to the agricultural safety field.

Method: This study identified ICT convergence service technology trends and representative serious accident types mainly occurring in agricultural activities. This study defined the major factors of farm work accidents and ICT to solve those accident factors including the sensor technology, wired/wireless communication technology and location information service, and applied them to prototype PCB for the development of an agricultural safety monitoring system.

Results: This study proposed an emergency monitoring system for farmers and a harmful environment monitoring system. The ICT technology to prevent farm work accidents can be summarized as sensing technology, ICT and network technology and user interface technology. This study also designed PCB module configuration and situation judgment algorithm as basic research for proposed monitoring system development.

Conclusion: The ICT-based agricultural safety monitoring research proposed in this study is expected to become the basis to build a future real time monitoring system, and also is expected to contribute to social safety and welfare service improvement for farmers.

Application: The ICT convergence farmer accident prevention system will make contributions to the prevention of serious farm work accidents.

Keywords: ICT, Agricultural safety, Farm work accident, Real-time monitoring system, Emergency situation

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1. Introduction

Korea's agriculture has grown quantitatively from the production aspect through mechanization, agricultural chemicals use, species improvement and the economies of scale since the 1960s. Meanwhile, occupational accident rate is continuously rising, due to recent agricultural population decrease, the aging of farmers and increase in

population returning to farms and rural villages. Therefore, the seriousness of solution to such a problem has emerged (Park et al., 2009). Solitary outdoor working cases increase, due to population aging and rural village population decline, and farmers returning to farms and rural villages are likely to be exposed to hazardous and harmful factors, since they cannot easily adapt to the new agricultural working environment.

Occupational accident rate in agricultural was 1.30%, and was reported as more than two times higher than total occupational accident rate, 0.59% (MOEL, 2012). Although the statistics has a limitation in reflecting the total occupational accident rate of farmers, measures to prevent such accidents are urgently needed, since high occupational accident rate has been shown in relation with farm work. In farm work accidents, the accident frequency of fall accidents while moving to work places is high to aged farmers, who are safety vulnerable class, and the cases of being engaged in farm work alone increase, which is connected to death accidents, due to rescue work delay upon accident occurrence. A suffocation accident by gas, due to hypoxia in an underground storage facilities of ginger roots (Lim and Bae, 2002), a poisoning accident by hydrogen sulfide gas in the livestock manure treatment facilities (RDA, 2013), and a stress accident by heat within agricultural vinyl house (Cho et al., 2010; You, 2012) occur steadily, which are difficult to be easily recognized by humans. Also, the number of deaths by traffic accidents caused by agricultural machines is steadily rising each year. These accidents and incidents can be prevented from being linked to more serious accidents and incidents, if a message is delivered to a third party quickly by detecting them in advance, or if a prior action is taken to recognize the danger situation in advance (NEMA, 2008). An agricultural safety service support system is required to be built in line with farm work situation, when it comes to a situation, for which first aid or quick action for emergency rescue is difficult, or to suffocation and poisoning accidents by gas.

Because the identification of farmer safety status and harmful environment of agricultural work is closely connected with safety, monitoring is the most vital part in farm work safety. The convergence technology combining ICT (information communication technology) is recently applied to industries overall, and therefore better services are offered. ICT convergence in the agricultural safety field will make recognize an accident and response to the accident quickly, when an accident related with farmer's farm work occurs. When dangerous level of hazardous gas concentration is detected through an installed wireless sensor inside of agricultural facilities with high risk of hazardous gas poisoning, a serious accident is judged to be prevented beforehand by delivering a danger signal to workers in real time. However, studies on ICT convergence have yet to be conducted in the agricultural safety field, and base research to build s safety management monitoring system is required.

This study proposes an ICT-based monitoring system on serious accidents that farmers face. To this end, this study investigates major farm work accident types and the need to prevent those accidents, reviews ICT convergence service utilization cases and technologies, and checks farmers' safety and ICT technology's applicability. This study is a basic research on agricultural safety field and ICT convergence, and is conjectured to contribute to the building of a monitoring system for farmers.

2. Agriculture and ICT Convergence Services

The development of ICT is rated to offer an opportunity to develop existing industries innovatively. ICT improves weaknesses and imitations that industries have, and offers a more valuable and new direction through more quick calculation, automation and accurate information delivery. ICT convergence technology in the agricultural field is defined as a technology improving productivity, efficiency and quality by applying digitalization technology, automatic control technology, RFID (radio frequency identification), USN (ubiquitous sensor network) wired/wireless communication, monitoring technology and complex control technology to agriculture (Kim et al., 2012). Concerning the convergence cases of agriculture and ICT, monitoring and remote control are supported by linking crops' growing environment with an automatic sensor in the facility horticulture and bare ground fruit field with smart farm services. Such a technology offers relevant information through application in real time via a mobile device like smartphone using wireless network technology in terms of the data detected in the sensor. In the livestock field, pigpen

environment is monitored, and feed intake is managed by using a temperature/humidity sensor, carbon dioxide gas sensor and CCTV-based video information in the pigpen management system. A system to store necessary data to DB in real time has also been built by installing various types of sensors including RFID or USN tag for collected data. The ICT convergence technology in the agricultural field is applied to efficient farm work management, agricultural products and distribution and livestock management monitoring.

IT paradigm recently develops from productivity-oriented industrial technology to human-oriented scientific technology, and ICT convergence technology is increasingly used for the scientific technology field enhancing the quality of life such as human's health, safety and welfare (Park, 2011; Yu et al., 2011). ICT convergence technology has enhanced a possibility to efficiently cope with futuristic accidents and disasters through combination with cutting-edge technology including sensor technology, big data, cloud, AI (artificial intelligence), GIS (geographic information system), mobile system, intelligent robot and wearable computing (Moon, 2013). A safety service using ICT convergence enables real time monitoring, and also enables to effectively cope with safety accident prevention through quick and accurate data collection and delivery. For instance, a study on ITC-based customized safety management service is carried out to prevent accidents of the socially safety vulnerable groups that socially increase gradually. Table 1 shows the application services for the safety vulnerable social groups using ICT (NIA, 2009).

Table 1. Application services for safety vulnerable social groups

Division	Areas where safety management is necessary	Related ICT application service (example)
Children	Kidnap, disappearance, crimes such as sexual violence, traffic accident, unexpected accident	Information provision, condition understanding, commuting to school notices, danger notices, personal safety, facility monitoring, and dangerous zone alarm devices
Elderly	Solitary household safety accident, traffic accident, disappearance, loitering, dementia, and health related emergency	Information provision, location information understanding, condition understanding, personal safety, residing facility monitoring, and emergency notices
Female	Abnormal accident, sex crime, and disappearance	Crime-ridden district monitoring, taxi safety, and notice in an emergency
Disabled person	Inadequate responses to disasters such as safety accidents during movements and fire	Road guide service, intelligent guide stick, and notice in an emergency
Foreigner	Inadequate responses to various accidents or fire	Video service in an emergency, warning and alarm in an emergency, etc.

The safety vulnerable groups in society include high risk groups such as children and the elderly. However, even a suggestion on the safety service support system for farmers showing high occupational accident rate has not been offered yet. Therefore, ICT technology utilization to reduce safety accidents including humans, social and economic losses caused by accidents during farm work will make contributions to the prevention and reduction of accidents.

3. Occupational Accidents in Agriculture

An emergency situation during solitary work, a traffic accident, a gas poisoning in livestock manure treatment facilities and a suffocation accident in the underground storage facilities of ginger roots and thermal stress within an agricultural vinyl house are reported as representative serious accidents caused during farm work. Figure 1 shows the examples of the agricultural working environment.

(a) Agricultural machine accident and solitary work

(b) Livestock manure treatment facilities

(c) Underground storing places of ginger roots

(d) Vinyl house

Figure 1. Safety accidents that mainly occur in agricultural fields

4,065 agricultural machine accidents occurred for recent four years (2009~2012), and there were 4,012 human victims (deaths: 354, the injured: 3,658), which increases continually each year [Figure 1 (a)]. The causes of agricultural machine accidents are mostly reported as safety ignorance and lacking management including negligent operation, noncompliance with safety rules and poor maintenance (NEMA, 2014). For every 100 cultivators, farm work accidents occurred to 0.79 cultivator, and traffic accidents occurred to 0.18 cultivator. As for age group, people in their 70s took up 38.1% and 60s 32.1%, and the accident rate of the aged farmers was 70% (RDA, 2012). Most accidents were surveyed to occur on the farm road (40%) and rice paddy and field (32%) in solitary work, and those accidents are connected to emergency situation in many cases. Especially, an accident of fall took up 33%, the most in terms of accident type, and accident recognition and response to the accident are difficult. Due to aging trend of agricultural population, practical preventive actions are needed, since the probability of accidents occurring to aged farmers, whose physical function is low, is high.

Pig's manure treatment facility is a dangerous place, where suffocation accidents can occur, due to highly concentrated hazardous gas in the closed spaces including septic tank, water collection tank, manhole, well and quiescent tank [Figure 1 (b)]. A serious accident took place in 1998, in which five workers were killed because of hydrogen sulfide poisoning during water collection tank motor repairing. A serious accident also occurred in which four family members died, due to hydrogen sulfide poisoning during a manure treatment facility cleaning and repairing (RDA, 2013). These suffocation accidents occurred by acute hydrogen sulfide poisoning, due mainly to the lack of oxygen in closed space (Lee and Lim, 2010). To prevent farm work accidents in the closed space like livestock manure treatment facilities, placing safety equipment, measuring gas concentration, ventilation and how to rescue upon an accident are recommended; however, accidents are steadily occurring. Accidents are caused, because of no easy

recognition, due to fundamental cause of the accidents, namely hazardous gases (hydrogens sulfide, oxygen concentration, ammonia, carbon dioxide and carbon monoxide).

In Seosan City and Taean County, the largest producing areas of ginger in Chungcheongnam-do in Korea, there are some 3,000 underground storage facilities of ginger roots. In 2009 and 2010, three people died in those areas, respectively, and about ten people also lost their lives for the past ten years. The main cause is reported to be hypoxia (Kwon et al., 2012), due to increase of oxygen consumption and carbon dioxide gas generation by temperature rise within the underground storage facilities of ginger roots (Lim and Bae, 2002). The underground storage facilities of ginger roots consist of horizontal tunnel structure with 7~8m under vertically from the aboveground entrance, 3~4m length to the left and right and 2m in height [Figure 1 (c)]. As safety measures to cope with such a cause, ventilation using a gas discharger, safety rule education and safety caution sign installation in front of the underground storage facilities of ginger roots are recommended, but much effect is not shown for accident prevention.

The cultivation area of Korea's agricultural vinyl house was some 50,000 ha as of February 2010, and is on the rise, as time goes by (Song and Kim, 2011). Studies have been carried out, centered on safety model research on the vinyl house structure for natural disaster prevention by heavy snow and gale as part of prevention against agricultural accidents (Cho et al., 2010; You, 2012). Meanwhile, few studies on farmers' safety within the vinyl house facilities are found [Figure 1 (d)]. Various types of occupational diseases within the vinyl house facilities such as headache, migraine, respiratory disorder, dizziness and visual impairment are shown. Oxygen deficiency is reported as one of the main causes of such symptoms. Dehydration is likely to occur by thermal stress, because of severe difference between indoor and outdoor temperatures, and the high temperature and humid environment. According to the work environment of vinyl house, breathing clean air coming out of the vinyl house, as well as air ventilation within vinyl house, is recommended; however, it is difficult for humans to recognize a dangerous situation.

The agricultural working environment is easy to be exposed to various dangerous situations and harmful factors unlike other industries, and workers are in the safety blind area in terms of response, when an accident occurs. Most serious farm work accidents were surveyed to occur in the limited danger detection situation with human's recognition capability, as well as change in the agricultural working environment, due to the aging of agricultural population and decrease in labor force. Therefore, the application of a safety system combined with ICT convergence technology can be efficiently for serious accident prevention of farm work.

4. Agricultural Safety Monitoring System Models

4.1 System structure

This study proposed a farmer emergency situation monitoring (i.e. farm work, agricultural machine operation), and safety management system on the safety of harmful environment of agricultural facilities (i.e. agricultural vinyl house, underground storage facilities of ginger roots and livestock manure treatment facilities). For the former, safety is judged on the basis of detected data by attaching a sensor to a wearable device or agricultural machine. In this way, the status of framers is delivered in real time. For the latter, warning and caution signals are offered to workers in real time upon abnormal status detection by attaching gas, temperature and humidity sensors to the agricultural facilities with high risk.

Figure 2 shows the conceptual diagram of the agricultural safety monitoring system proposed in this study. For the emergency situation monitoring of farmers, a method to attach a wearable device including a movement sensor and deliver abnormal status information, and a method to deliver danger situation by attaching a movement sensor to agricultural machines (i.e. cultivator and tractor) can be applied. A detection technology using a wearable device such as an accelerator sensor, a temperature sensor and a pressure sensor is to detect heart rate and body temperature, which are bio-signals, from clothes, cap, shoes and bracelet, or detect physical signals, and process data. Network technology is to send detected data such as the status and location of farmers

using wired/wireless communication network, and send the stored data to a device wearer, a third party or a related agency. Here, user interface technology is a visually expressing information visualization technology to OSD (on screen display) to GPS (global positioning system), monitoring system or a third party and related agency.

Agricultural facility safety situation monitoring is to detect the degree of danger of harmful materials exposed to the inside of agricultural facilities, and deliver the sensed data to a worker or related agency. Here, a sensor-based detection technology, network technology using wired/wireless communication network, and user interface technology expressing for a user to easily recognize danger situation in real time are required. The sensor technology is a sensor node system receiving and sending data from a sensor attached to the inside of facilities (e.g. USN). A detection sensor is to monitor oxygen, hydrogen sulfide, ammonia, carbon dioxide, temperature and humidity exposed according to agricultural facilities in real time. The network technology includes hardware and software like wired/wireless module that delivers detected information to a worker or central DB. Also, danger situation is delivered via warning or notice upon user's access to agricultural facilities by using NFC (near field communication) (e.g. Zigbee, Bluetooth, WiFi) and user's mobile devices (e.g. smartphones, wearable device). The user interface technology, which is on the display on the monitoring screen, is related with interface technology such as information visualization technology, early warning and notice.

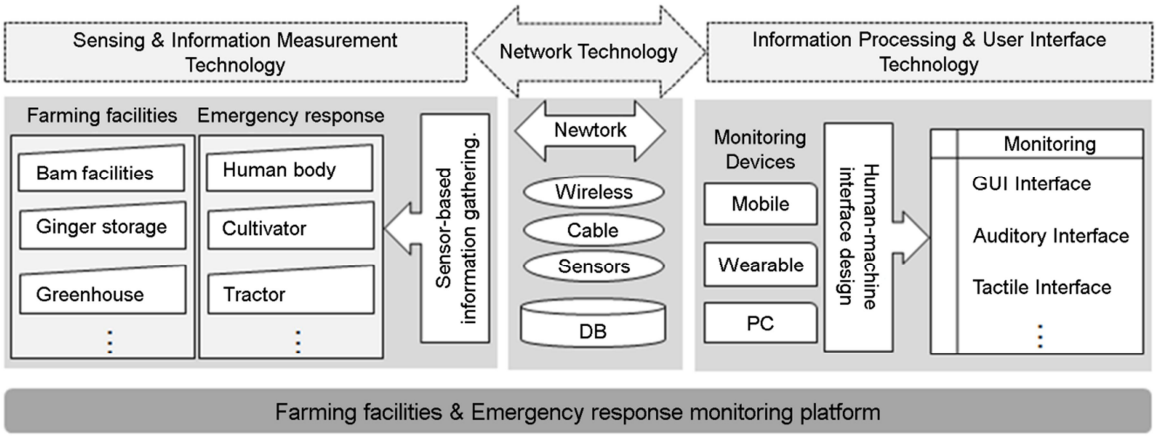


Figure 2. System conceptual diagram for agricultural safety and ICT convergence technology

4.2 Application system design

• Farmer emergency situation monitoring: Emergency situation emergency call

Farmer emergency situation monitoring system is to analyze wearer's movement and bio-signal, and a confirmation message is requested to the wearer automatically, if abnormal status is detected. If there is no response from the wearer, it is judged as a real emergency situation. Here, the status information and GPS information of the farmer is offered automatically to a third party (e.g. guardian) or related agency (e.g. emergency center, hospital). The system configuration can be divided into sensor node, communication module and monitoring module as shown in Figure 3. To the detection part, a 3D acceleration and gyroscope sensor, an infrared ray sensor and a temperature sensor can be applied. As for the communication module, the data in the sensor node is delivered to central DB using the wireless communication network protocol defined in the system, and the status information and GPS information are sent to the wearer, a third party and a relevant agency in real time. The communication module sends data to DB by applying CDMA and 3G network, and sends information to a third party and the relevant agency through the Internet/WLAN and 3G network from the DB. The monitoring module can be divided into main monitoring and

sub-monitoring. Through the main monitoring system, all wearers' real time situation, accident situation, accident type and statistical data can be checked from the central DB center. Real time check is possible by the designated wearer, related third party or agency in terms of sub-monitoring. A third party can identify the accident person's location via emergency call signal-delivered message through cellphone, and the relevant agency can check the wearer's information (age, blood type, medical history) and the person's location.

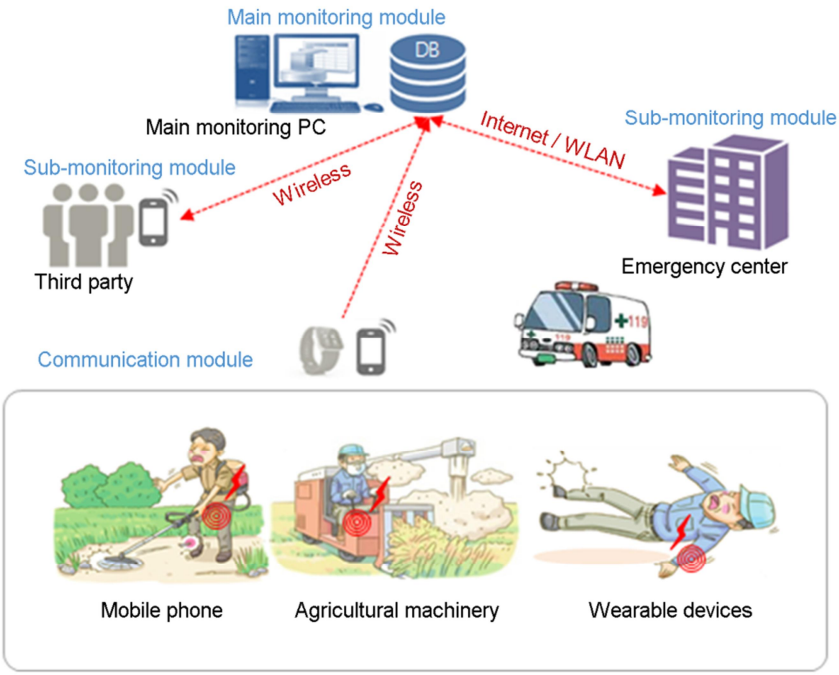


Figure 3. Structural diagram of the farmer emergency situation monitoring system

• Farm work facility environment safety monitoring: Prevention of access to dangerous and harmful regions

Farm work facility environment safety monitoring system offers the danger information of hazardous materials measured by a sensor. The system configuration can be divided into sensor node, communication module and monitoring module as shown in Figure 4. The sensor node includes a sensor detecting oxygen, carbon monoxide, carbon dioxide, ammonia, temperature and humidity affecting humans. The communication module is designed to send the data collected from the sensor node using NFC or wired communication via the data protocol defined in the system. The monitoring module can be divided into main monitoring and sub-monitoring, namely the main monitoring through which central DB center checks and manages overall safety situation, and the sub-monitoring through which information is sent to farm work facility-related people and those who enter the facilities. The sub-monitoring system can deliver warning and caution signals to the accessor's cellphone and at the entrance through NFC network for the farm work facility accessors to safely enter and go out, when they approach closely.

4.3 Implementation of monitoring system

This study manufactured a PCB (printed circuit board) as an initial phase for the development of a farmer emergency situation monitoring system. Figure 5 shows the shape of the prototype PCB that was implemented in this study. The size of the manufactured PCB is 7cm (width) x 5cm (length), and the PCB was designed in a way to be attached to shoe's insole. Five sensors

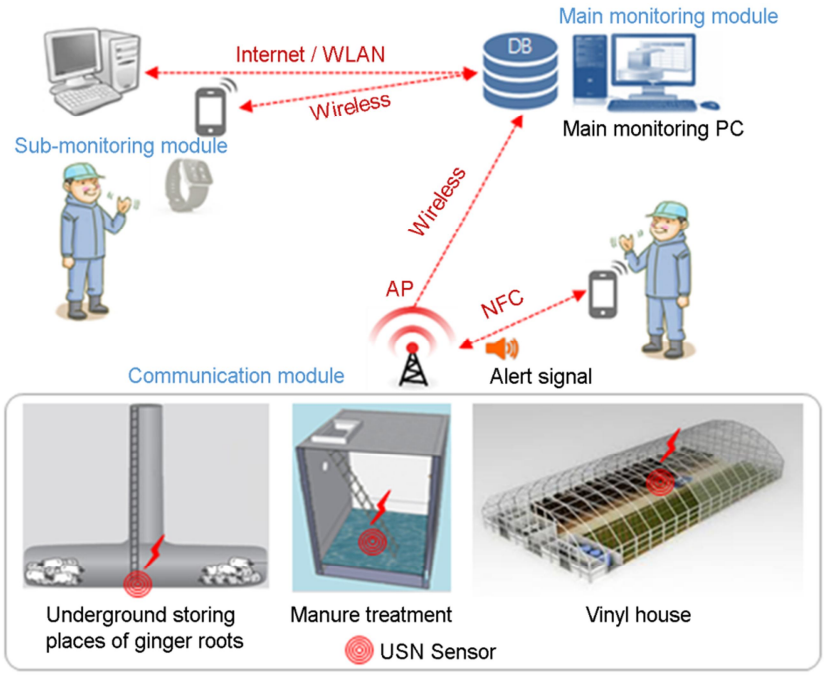


Figure 4. Structural drawing of the farm work facility environment safety monitoring system

are used as major sensor module, and they detect body-worn status and abnormal activity. Body-worn status detection consists of a pressure sensor measuring pressure imposed upon from the wearer's body, a temperature sensor using the temperature difference of inside and outside, and an infrared ray sensor judging the status of an object nearby. For wearer's abnormal activity detection, a 3D accelerator sensor related with wearer's physical aspect, and a gyroscope sensor are used. The GPS module receives and sends the current location information through the communication module, if an emergency situation occurs to a wearer. This study installed CDMA module for wireless communication, and sends the location and status information to a third

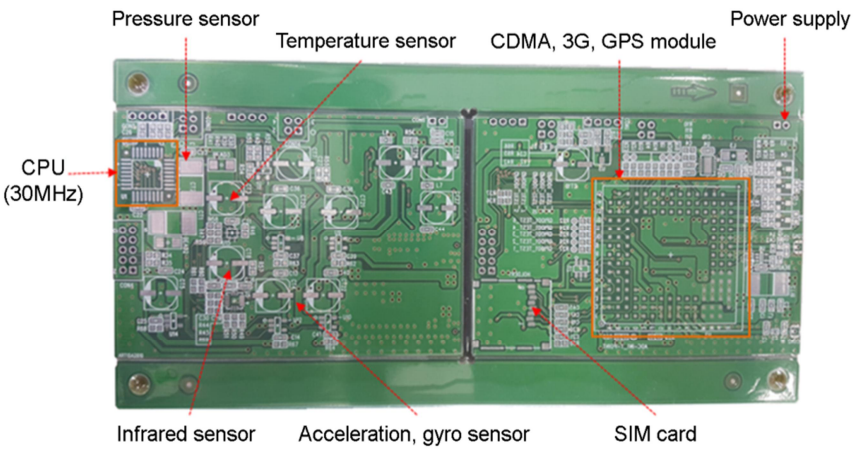


Figure 5. Prototype PCB for module

party or related agency. PCB consists of CPU in charge of controlling each module and judging emergency situation, and SIM card to identify wearer's ID. The power supply has minimized power consumption that may occur with unnecessary operation by not supplying power, when a worker does not wear the device.

The main operation flow of farmer emergency situation PCB module can be configured with body-worn status detection, abnormal status detection and data sending. Body-worn status detection is to judge the status of wearing on the body, and judges based on temperature, pressure and infrared ray sensing data. The system operates, when it is judged as the status of wearing. The wearer's abnormal status detection is conducted with 3D acceleration and 3D gyroscope sensing data on physical movement, and when the data deviates from normal status range, it is judged as abnormal status. The location information from the GPS module and abnormal status are sent to a third party or related agency as a message by the wireless communication module. Figure 6 shows the example of algorithm applied to the emergency situation monitoring system.

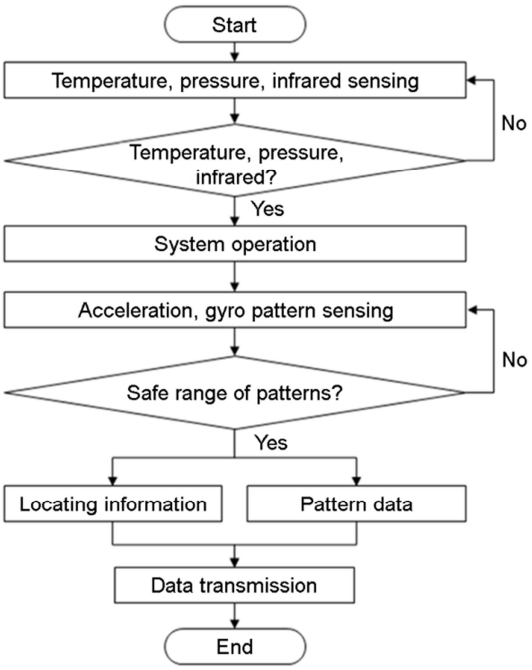


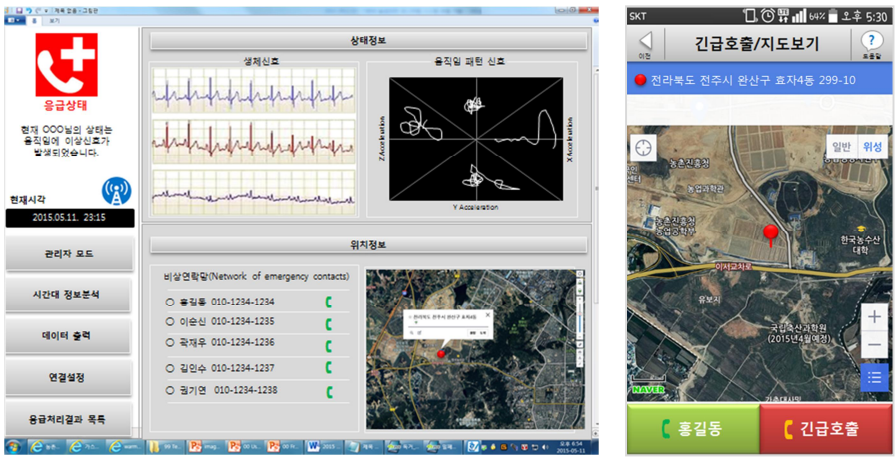
Figure 6. System flow chart

4.4 Application system's UI design

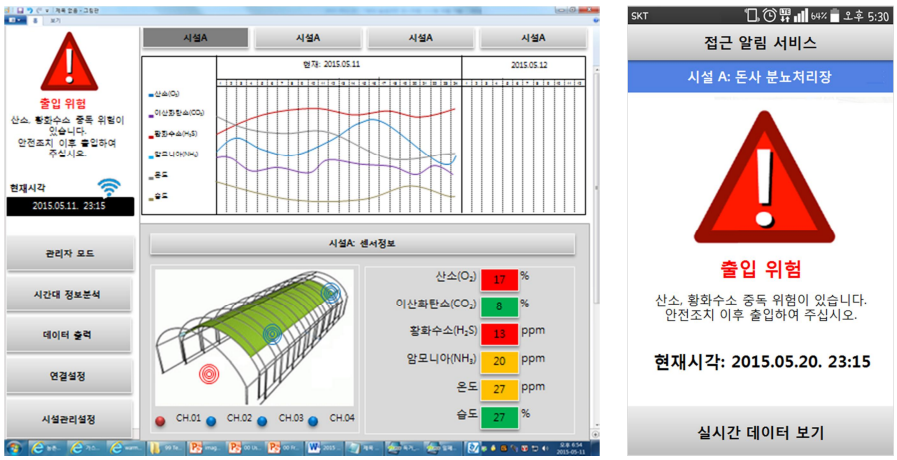
The user interface technology is design on OSD, and software and hardware related with the interaction between system and user. GUI (graphical use interface) visually expressing for a user to easily monitor, and a method to deliver information with auditory and visual senses are included. The user interface technology is to express and deliver information by parsing sensing data for a user to easily recognize and utilize. Figure 5 shows the example of major UI drawing of the application system proposed in this study.

As for the farmer emergency situation monitoring system, Figure 7 (a) shows the examples of main monitoring displayed on the PC screen, and displayed on the cellphone. Through main monitoring, the injured person's behavior pattern, bio-signal, emergency contact network and the status of an action taken can be checked. Figure 7 (b) shows the UI design of agricultural facility safety

monitoring system. Main monitoring PC, farm management PC, farmer's cellphone and facility entrance warning device can be included. UI needs design such as information structure, layout, color, sound and vibration for a user to easily recognize the situation of the inside of the facilities.



(a) Emergency calls: Main monitoring PC and smartphones



(b) Agricultural facility: Main monitoring PC and smartphones

Figure 7. Applied system UI design

5. Conclusion and Further Research

Because accident frequency increases, due to the increase of aged farmers, decrease of farm house members and augmentation of solitary work frequency in Korea's recent agricultural working environment, a quick accident recognition and response system is required. This study proposed an agricultural safety monitoring system (ASMS) using ICT technology to effectively cope with emergency situation occurrence of farmers and farm work facility dangerous situation. This study defined the concept of agricultural safety monitoring system, ICT digitalization sensing technology, network technology and interface technology, and manufactured

a PCB module for their implementation. Although this study has limitations to apply to sites as a basic research to build farmer safety monitoring system, the study result can innovatively reduce safety accidents occurring due to the change in agricultural working environment.

To more realistically apply the ICT-based farmer safety monitoring system, integration with various systems is needed. First, DB integrating farm work accidents through cloud environment application. Second, building network infrastructure for information transmission including third party, related agency (e.g. local government, local agricultural technology center,) farmer and medication institution. Third, emergency transport system, emergency treatment support and prevention system linked with medical institutions. Studies on sensor-based network (USN) considering agricultural working environment, algorithm design judging dangerous status and hazardous environment, ergonomic experiment analysis related with human body and activity, and software and hardware development should be carried out. Furthermore, pilot application for onsite verification, and operating and managerial measures for system and utilization planning for collected big data need to be considered. The ICT-based agricultural safety monitoring system design proposed in this study is expected to be helpful to building farm work safety management system.

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References

Cho, J.U., Lee, E.J. and Nam, J.S., Model Development by Structural Analysis of Vinyl House at Heavy Snow, *Journal of academia-industrial technology*, 11(8), 2727-2733, 2010.

Kim, S.S., Kim, S.H., Lee, J.W. and Kang, H.J., USN Based Agricultural IT Convergence Technology Trends. *Electronics and Telecommunications Trends*, 26(6), 97-107, 2012.

Kwon, S.C., Lee, S.J. and Jeong, M., Work-related hazards among farmers, *Journal of Korean Med Assoc*, 55(11), 1046-1053, 2012.

Lee, E.Y. and Lim, J.S., Current Status and Perspectives of Livestock Environment Improving Agents for the Characteristics and Control of Swine Manure Odor. *Kor J Microbiol Biotechnol*, 38(3), 244-254, 2010.

Lim, H.S and Bae, G.R., Investigation of Health Hazards in the Underground Storage Facilities of Ginger Roots. *Journal of Preventive Medicine and Public Health Med*, 35(1), 72-75, 2002.

MOEL (Ministry of Employment and Labor). 2011 Industrial Accident Examination. 2012.

Moon, Y.H., Future technology trends, and promising technologies: Select 10. *Future Technology Seminar*. 2013. 10. 2013.

NEMA (National Emergency Management Agency). Disaster Comprehensive Situation Analysis and Forecast-2014. 10. 2014.

NEMA (National Emergency Management Agency). Development of u-Disaster Prevention Management Technology for Man-made Disaster based on Sensor Network. 2008.

NIA (National Information Society Agency, ICT-based safety management strategies for vulnerable groups. *IT & Future Strategy*.

No.3. 2009.

Park, J.H., The Trend of ICT Services for Life-support. *Electronics and Telecommunications Trends*, 27(4), 21-28, 2011.

Park, K.S., Kim, C.H., Lee, K.S., Kim K.R. and Kim, H.C., Development of Indicators for Safety Supervision on Farm Work and Life Environment of Farmer. *Journal of the Ergonomics Society of Korea*, 28(4), 77-82, 2009.

RDA (Rural Development Administration). 2012 Farm Work and Traffic Accident Occurrence Frequency by Agricultural Machine. 2012.

RDA (Rural Development Administration). Safety and Health Management of Swine Farmers. 2013.

Song, J.H. and Kim, T.U., The Vinyl house Automatic Control System Using Aging Society Of the Farm Village. *Journal of Academia-industrial Technology*, 12(7), 3164-3168, 2011.

You, K.P., Evaluation of Snow Load Using a Snow Simulation Wind Tunnel for Single Span and Multiple Span Green House Roofs. *Journal of Architectural Institute of Korea*, 28(7), 73-80, 2012.

Yu, E.S., Seo, J.Y. and Lee, M.H., Ways to Activate Citizen-oriented Science and Technology. *Science and Technology Policy Institute (STEPI)*, Policy Research 2011-9, 2011.

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