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Development of Workplace Environmental Monitoring Systems Using Ubiquitous Sensor Network

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***Abstract*—**In this study, workplace environmental monitoring systems were established using USN(Ubiquitous Sensor Networks) and LabVIEW. Although existing direct sampling methods enable finding accurate values as of the time points of measurement, those methods are disadvantageous in that continuous management and supervision are difficult and costs for are high when those methods are used. Therefore, the efficiency and reliability of workplace management by supervisors are relatively low when those methods are used. In this study, systems were established so that information on workplace environmental factors such as temperatures, humidity and noises is measured and transmitted to the PC in real time to enable supervisors to monitor workplaces through LabVIEW on the PC. When any accidents have occurred in workplaces, supervisors can immediately respond through the monitoring system and this system enables integrated workplace management and the prevention of safety accidents. By introducing these monitoring systems, safety accidents due to harmful environmental factors in workplaces can be prevented and these monitoring systems will be also helpful in finding out the correlation between safety accidents and occupational diseases by comparing and linking databases established by this monitoring system with existing statistical data.

***Keywords*—**Ubiquitous Sensor Nework, LabVIEW, Environment Monitoring.

I. Introduction

RECENTLY, as our society has been gradually advanced, attention to the formation of environment friendly and better working environments has been increasing. Accordingly, the necessity of continuous management of workplace environmental factors has been increasing.

The current workplace environmental factor measurement regulations of the Korea Occupational Safety and Health Agency specify that workplace environmental factors should be periodically measured at least once per 6 months; provided that the number of times of measurement may be adjusted to once per year or four times per year based on the levels of measurement in the past[1].

However, although the aforementioned measurement of workplace environmental factors through direct sampling methods enables finding accurate values as of the time points of measurement, those methods are disadvantageous in that continuous management and supervision are difficult and costs are high when those methods are used.

In particular, as concern about and attention to occupational diseases resulting from exposure to harmful factors in workplace have been increasing in relation to manufacturers, objective indicators of harmful factors including various environmental factors should be disclosed and continuously managed. According to the present state of occupational diseases in the 2009 industrial disaster analysis statics of the Korea Occupational Safety and Health Agency, the most frequent disease was pneumoconiosis followed by noise induced deafness and poisoning by certain chemicals in order of precedence and special health examinations conducted by the Ministry of Labor on those with findings of occupational diseases also show similar states [2].

In this respect, in this study, workplace environmental monitoring systems were established utilizing the Ubiquitous Sensor Network technology to enable continuous measurement of workplace environmental factors.

The Ubiquitous Sensor Network technology is networks configured to enable wireless collections of information collected by various kinds of sensors. This technology assigns IPs to individual sensors so that the pieces of information measured at certain locations can be transmitted quickly and accurately.

USNs (Ubiquitous Sensor Networks) for performing the aforementioned function are generally composed of sensor nodes that sense and process various events and sink nodes that collect data from sensor nodes and process the data and are connected to existing wire/wireless networks or the Internet, etc.

Therefore, if the workplace environmental monitoring systems utilizing the USN (Ubiquitous Sensor Network) technology proposed in this study are established, data measured by environmental sensors can be provided in real time and it is expected that this will enable continuous management without any spatial or temporal constraints.

II. Related Works

In this study, a real time workplace environmental monitoring system with sensor in workplaces using the USN technology was established. In particular, these systems were designed to enable users to easily recognize the values of individual factors through interlocking between TinyOS based

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USN sensor nodes and LabVIEW program for displaying measured data.

In addition, prior studies of sensor developed by now and previous studies were conducted to select measurable factors such as temperatures, illumination, humidity and noises.

In general, each workplace environmental monitoring system utilizing USN consists of three parts-sensor nodes, a sink node and a PC and a construction plan showing individual components is as per "Fig.1"[5][6].

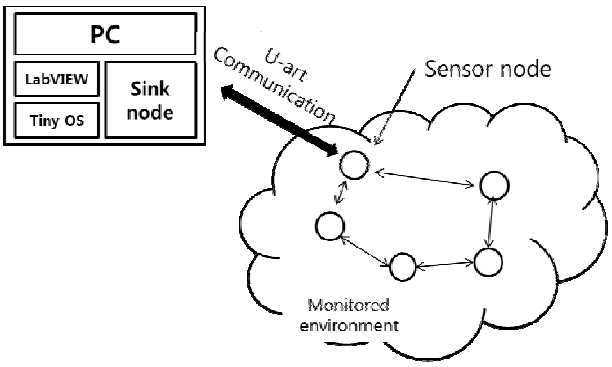

Fig. 1 Ubiquitous Sensor Network construction plan

The sensor nodes serve the role of measuring in accordance with the characteristics of individual sensors and transmitting measured data to the sink node.

The sink node converts the data transmitted by the sensor nodes in order to display the data and the converted data are automatically stored in the database of the PC connected to the sink node[4].

Finally, the PC stores the transmitted data in its DB and provides the data in forms easily perceivable by users using the LabVIEW program. That is, through the data 'storage-analysis-display-monitoring' processes, environmental factors can be grasped in real time.

Each of the workplace environmental monitoring systems proposed in this study is largely divided into a hardware part and a software part and hardware part consists of the sensor nodes[6], sink node and PC mentioned above and the software part consists of TinyOS for data transmission, analysis and displays and LabVIEW.

III. Design

Existing workplace environmental monitoring systems measured and managed environmental information non-continuously and thus management by those systems was relatively less efficient and reliable.

Therefore, studies recently conducted in Korea/foreign countries have been establishing systems to enable real time measurement of environmental factors and in this study, too, environmental monitoring systems using the USN technology was established[5].

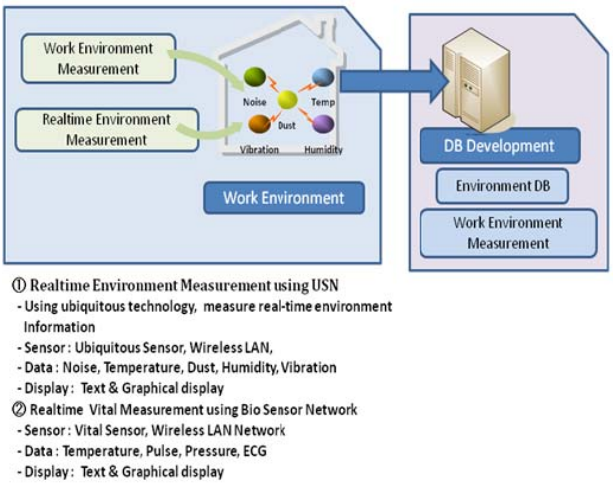

Fig. 2 Schematic diagram of the USN environmental monitoring system

As shown in "Fig.2", the monitoring systems developed in this study were designed to enable measuring representative environmental factors such as temperatures, illumination, humidity, noises, etc. in real time using sensors and establishing the measured data into DBs to utilize them as statistical data or immediately perceive any risk factors occurring and take necessary actions. The USN environmental sensors have the advantage of wireless data transmission and thus these do not require writing work for existing facilities and provide excellent expandability since additional sensors can be installed [5].

A. System Design

Reasons for using ubiquitous sensor networks for continuous measurement for long periods of time as with the workplace environmental monitoring systems proposed in this study are as follows. First, the electric energy that can be supplied to each sensor node is limited for low power consumption and continuous measurement for long periods of time. In addition, since most sensors use batteries to secure their own power, the sensors can be used for long periods of time only when power consumption is minimized. Second, it must be possible to establish the system at low casts. Since the range of measurement per sensor node is generally limited, multiple sensor nodes are necessary to measure environmental factors in an entire workplace. Therefore, to secure a sufficient number of sensor nodes, it must be possible to establish the system at low costs. Third, the sensor should be small in size. When the sensors are installed in workplaces, it should be possible to attach them to the ceiling or walls and they should not obstruct work.

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TABLE I
EXAMPLES OF USN ENVIRONMENTAL SENSORS

Division	Model	Specification	Division	Model	Specification
Infrared temperature sensor		‣Infrared sensors are used -Non-contact type for body temperature measuring	Hmote-Zigbee		‣TinyOS based real time sensor network ‣Built-in PCB antennas, exterior expansion antennas and expansion ports for diverse sensor expansions are provided ‣Programming data can be sent and received through USB ‣Power management function, diverse sensor functions(temperature, illumination, humidity mike)
Air sensor module		‣Co2 measuring function (absolute value) -Co:10~1000ppm ‣ VOCs measuring function (relative value) ‣ NO2 measuring function(relative value) ‣ DUST measuring function -Fine dust of 0.1 ㎛ can be measured ‣ Temperature/ humidity measuring function			

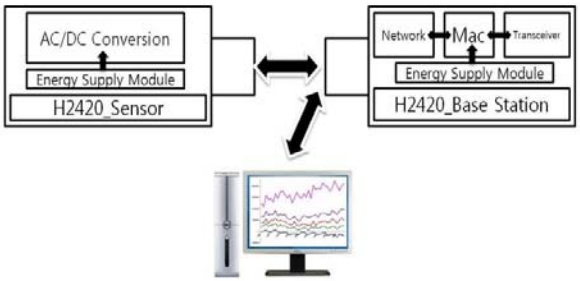

Fig. 3 Hmote2420 sensor node construction plan

As mentioned earlier, each ubiquitous sensor network consists of sensor nodes, a sink node and a PC and the reliability of the sensor nodes for data measurement and transmission is very important. A construction plan for the sensor nodes used in this study is as follows [6].

In particular, as shown in "Table I", Hmote2420 sensor nodes were used and measurable factors included temperatures, illumination, humidity and noises. Data measured through the aforementioned sensor nodes are stored in the DB through the sink node and the monitoring system's actually applied parts are divided into a monitoring system for processing the data received as one piece in real time and an analysis system for accumulated data. The monitoring system provides the data values measured in real time as interfaces that can be easily perceived by users and the workplace analysis system can be used to set reference values considering work environmental characteristics by type of general industries and conduct multidimensional analyses using accumulated data.

The workplace analysis system is divided into basic information obtained using the reference data on basic environments in workplaces of the Korea Occupational Safety and Health Agency and a real time environmental measurement system using environmental sensors installed in workplaces. In particular, since those environmental factors that can be measured with the environmental monitoring system directly affect work in many cases, each of these environmental factors can be analyzed in real time and emergency situations can be immediately responded based on the contents of analyses [5].

B. Interface Design

The most important thing in environmental monitoring systems using USN is how efficiently and accurately delivers the data collected through sensor nodes to users. In particular, previous similar studies provided simple forms of interfaces using Visual Basic or programming languages. However, user interfaces to be provided for simple and clear displays of workplace environmental information are limited. Therefore, in this study, in order to provide interfaces that could be easily understood, a system was established through interlocking with the LabVIEW program.

The LabVIEW program is the only system design software that provides tools necessary to establish measurement and control applications and it is advantageous in data storage and reporting through displays.

In particular, existing environmental monitoring systems utilizing ubiquitous sensor networks provided simple forms of outputs and thus there were difficulties in comparison between changes overtime and simultaneous displays of different factors. However, the aforementioned disadvantages could be relieved utilizing the LabVIEW program [23].

Details of the system established through the LabVIEW program in this study are as follows.

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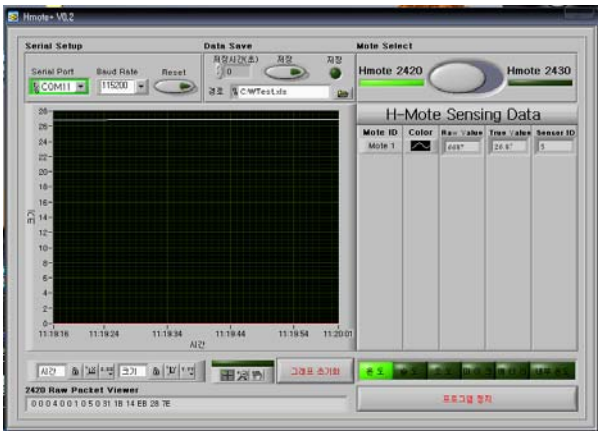

Fig. 4 Example of temperature measurement

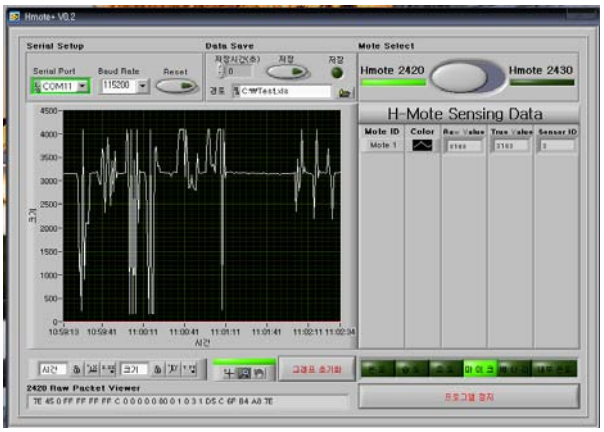

Fig. 5 Example of noise measurement

The above "Fig. 4" through "Fig. 6" are examples of environmental monitoring systems established with the LabVIEW program. As shown in the Figures, changes in each factor measured are made easily recognizable using USN environmental sensors.

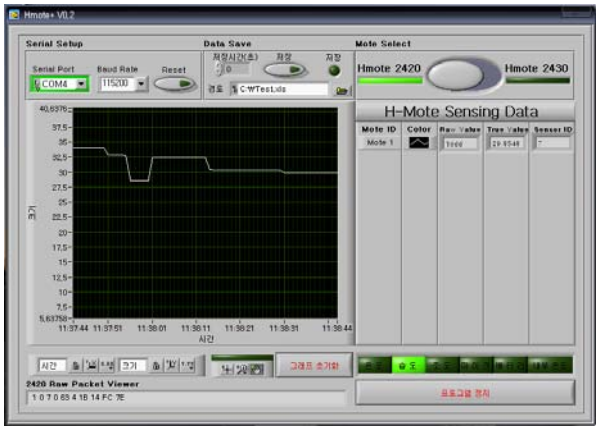

Fig. 6 Example of humidity measurement

IV. Conclusion

In this study, workplace environmental monitoring systems were developed utilizing the USN (Ubiquitous Sensor Network) technology. Existing workplace environmental information non-continuously and thus problems such as the lack of efficiency and reliability of workplace management occurred.

Therefore, in this study, the aforementioned problems in existing monitoring systems were corrected and monitoring systems were established so that workplace environmental factors could be measured in real time and managed altogether.

In particular, USN sensors can be established in relatively small sizes with low power consumption and low costs and can measure workplace environmental factors such as temperatures, humidity, illumination and noises in real time and send the data to the server. In addition, monitoring systems were established using the LabVIEW program so that transmitted data can be easily recognized by managers. The workplace environmental monitoring systems proposed in this study are expected to enable measuring and monitoring workplace environmental factors in real time and responsible managers' immediate responses when sudden abnormal situations have occurred. In addition, the systems are expected to be helpful in finding out the correlation between safety accidents and occupational diseases through the establishment of databases and linkage with existing statistical data.

For future studies, we propose monitoring systems that can not only measure workplace environmental factors but also measure workers' biometrics in real time to enable integrated management of environmental factors and biometrics.

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