Real-time Monitoring Technology for Preservation Environment of Archives

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1. A Brief Summary

Archives, libraries, and museums that manage our vital assets are faced with the threat of harmful environmental factors such as global warming, air pollution, etc. Therefore, a system that can identify harmful factors within repositories and can continually manage them is needed. Many organizations have researched damage prevention methods for physical and biological damages occurring in short periods, but a real-time monitoring technology for archives from long-term exposure to harmful factors within repositories is a new challenge.

National Archives of Korea applied IT and ET to research "Real-time Monitoring Technology for Preservation Environment of Archives", and submitted a patent application and developed a prototype for this technology. When the product is commercialized, it is expected to be widely used in multi-use facilities in areas of large floating population and areas which require clean air such as hospitals, subway stations, etc. as well as archives management agencies, libraries, and museums.

** Patent Application: 2010-2011 accuracy verification system and dilution device for harmful gas sensors*

2. Purpose and Need

Real-time monitoring of factors that are harmful to not only archives, but also to human body is a very important technology for multi-use facilities such as archives preservation, hospitals, and subway stations.

Until now, measurement was only limited to preservation environment of partial storages when harmful factors were identified, but with the use of Ubiquitous Sensor Network (USN), the preservation environment can be monitored in real-time accurately and reliably.

When such system is implemented, entire facility can be measured and monitored continuously, and minimize archives damage during fire and emergency situations through quick response.

3. Sensor Monitoring Technology

In Korea, 'Subway Mall Air Quality Management System' and 'Ministry of Environment's Automatic Air Pollutant Emission Concentration Measurement System' are the representative cases that combined USN technology, and some studies are underway overseas through projects such as IMPACT and MASTER.

1) IMPACT (Innovative Modeling of Museum Pollution and Conservation Thresholds)
Pollutants in Europe's museum preservation facilities include SO_2, NO_x, O_3, H_2S, HCHO, VOCs, etc. Among them, SO_2, NO_x, and O_3, are reported to accelerate the damage of archives and relics by activating the decay of organic matter.
IMPACT project measures the deposition velocity of SO_2, NOx, and O_3 within the test chamber that can artificially change the temperature, humidity, and light. It also developed a model that can measure the environmental pollution levels within the storage of museums by researching the mechanism of such reactions.

2) MASTER (Preventive Conservation Strategies for Organic Objects in Museums, Historic Buildings, and Archives)
MASTER project is measuring corrosive properties of archives in various physical and chemical conditions and based on such results, it is developing an early warning system that can evaluate harmful factors. The managers of repositories will be able to utilize these study results to establish practical preservation strategies.

4. Environmental Standards of Archives Preservation Facilities of Various Countries

Archives of various countries are appointing environmental standards of preservation facilities as standards or laws in order to carry out safe records management.

Enforcement decree item 6 of Korea's Records Management Act has set the preservation environmental standard of permanent archives management agencies as temperature, humidity, air quality, and intensity of illumination.

For temperature and humidity, there are detailed standards for each material quality such as paper records, electronic records, audio-visual records, and administrative artifacts. Air quality is subdivided into 7 items which are PM-10, SO_2, NOx, O_3, HCHO, CO, and VOCs. Also, intensity of illumination is regulated through subdivision of repositories and exhibition halls, and the details are shown in <Table 1>.

<Table 1> Environmental standards of preservation repository in National Archives of Korea

Classification	**Paper Records**	**Electronic Records**	**Audio-visual Records**	**Administrative Records**
Temperature (℃)	18-22	18-22	Film: -2 to 2 Magnetic Media: 13-17	18-22
Humidity (%)	40-55	35-45	Film: 25-35 Magnetic Media: 35-45	40-50
Air Quality	Particulate Matter (PM10): 50 ㎍/㎥ or less Sulfur dioxide (SO_2): 0.05ppm or less Nitrogen oxides (NOx): 0.05ppm or less Ozone (O_3): 0.05ppm or less Formaldehyde (HCHO): 120 ㎍/㎥ or less Carbon monoxide (CO): 10ppm or less Volatile organic compounds (VOCs): 400 ㎍/㎥ or less			
Lighting	100 to 300Lux for repositories, 50 to 200Lux for exhibition halls (based on the original exhibition)			
Preservation Facility Equipment	Automatic fire extinguishing facilities, security equipment (intrusion prevention), temperature / humidity monitors, fumigation equipment, deacidification equipment			

** Microfilms shall apply to the preservation environmental standards of magnetic media.*

International standard ISO 11799 for archives preservation along with standards for Australia, UK, and U.S. are shown in <Table 2>.

<Table 2> Environmental standards of preservation facilities of ISO and various countries

Classification	ISO	Australia	UK	USA
Basis	ISO 11799 (Archives preservation facility)	Standard for Physical Storage	BS 5454-2000 BS 4971-2002	New guidelines of NARA II
Preservation Library	1. Location of library 2. Architectural considerations 3. Disaster preparedness 4. Air circulation adjustment	1. Location of library 2. Architectural considerations 3. Disaster preparedness 4. Air circulation adjustment	1. Location of library 2. Overall architecture 3. Architectural finishes 4. Disaster preparedness	1. Overall architecture 2. Architectural finishes 3. Disaster preparedness 4. Air circulation adjustment
Preservation Environment	**1. Temperature (℃) / Humidity (%)** <Paper documents> 18 ± 1/30 ~ 50 <Black and white films> 21 ± 1/15 ~ 50 <Color films> 2/15 ~ 30 <Audio/Video> 17 ± 20/20 ~ 30 **2. Air Quality** <Dust> 50 $\mu g/m^3$ <NOx, SO_2, O_3> **3. Lighting** <Repository> UV control <Exhibition hall> 50Lux	**1. Temperature (℃) / Humidity (%)** <Paper documents> 20 ± 2/45 ~ 55 <Black and white films> 18 ± 2/35 <Color film> -5/30 ~ 40 <Audio/Video> 18 ± 2/30 ~ 40 <Electronic media> 18 ± 2/30 ~ 40 **2. Air Quality** <Dust, CO, acid gas, mold spores> **3. Lighting** <Repository> UV filters Time control switch	**1. Temperature (℃) / Humidity (%)** <Paper documents> 16 ~19 / 45 ~ 60 <Black and white films> 18/30 ~ 50 <Color film> -5/30 <Audio/Video> 16/35 <Electronic media> 20 ± 2/35 ~ 45 **2. Air Quality** <NOx, SO_2, O_3, CO_2> **3. Lighting** <Repository> 100 ~ 300Lux <Exhibition hall> 50 ~ 200Lux	**1. Temperature (℃) / Humidity (%)** <Paper documents> 21 ± 1/40 ~ 50 <Black and white films> 18 ± 1/27 ~ 33 <Color film> -4 ± 1/27 ~ 33 <Audio/Video> 18 ± 1/32 ~ 38 **2. Air Quality** <Dust, SO_2, NO_3, O_3> **3. Lighting** <Repository> Light for halls and operating bookshelves

Preservation Facility Equipment	1. Facilities for fire detection 2. Fire extinguishing facilities 3. Security equipment (intrusion prevention) 4. Temperature and humidity monitor 5. Dust removal 6. Microbial treatment	1. Facilities for fire detection 2. Fire extinguishing facilities 3. Security equipment (intrusion prevention) 4.Temperature and humidity monitor 5. Dust removal	1. Facilities for fire detection 2.Fire extinguishing facilities 3. Security equipment (intrusion prevention) 4. Dust removal 5. Records condition analysis 6. Restoration treatment of fumigation and deacidification	1. Facilities for fire detection 2. Fire extinguishing facilities 3. Security equipment (intrusion prevention) 4.Temperature and humidity monitor

The general features of environmental standards of preservation repository of NAK and various other countries are as follows.

In the case of Korea, there are temperature and humidity standards for electronic and magnetic medias (including microfilms), and added detailed specification of air quality standards for HCHO, VOCs, in addition to, PM-10, SO_2, CO, NOx, O_3, etc.

In addition, for intensity of illumination, a detailed standard is presented by dividing between the repository and exhibition hall of the originals.

The area of preservation equipment is regulated in consideration to the need of preservation environment of each country.

5. Real-time Monitoring Tools Development for Preservation Environment

NAK developed real-time monitoring tools appropriate to the repository environment of Korea in order to minimize damages to archives, and the procedures are as follows:

1. Harmful factors detection method, and technology and equipment selection that complies to global technology practices and archives management laws related to ubiquitous sensor monitoring

2. Design and production of Printed Circuit Board (PCB) that can detect harmful factors simultaneously

3. Wired and wireless data communication and storage system

4. Device design, case production, implementation of real-time monitoring system, etc.

1) Selection of ubiquitous gas sensor

The gas detection sensor that measures harmful factors is a device that detects specific gas within gases and converts it to electrical signal that can be measured. There are the following kinds of methods: Semiconductor, electrochemical, catalytic combustion, solid electrolyte, thermal conduction, optical, etc.

Among such sensors, methods of electrochemical, semiconductor, infrared, and optical are generally used to measure environmental factors; but in order to develop tools, NAK selected sensors based on Indoor Air Quality Act and atmospheric environment test methods.

Consideration for sensor selection included the following: Sensor characteristic evaluation, appropriate measurement range for environmental criteria during selection, high sensitivity, reliability of measurement data, independence from the surrounding environment, durability, ease of maintenance, etc.

As a result, light scattering sensor was selected for PM-10; electrochemical sensor for SO_2, CO, NOx, O_3, and HCHO; and photo ionization sensor for VOC.

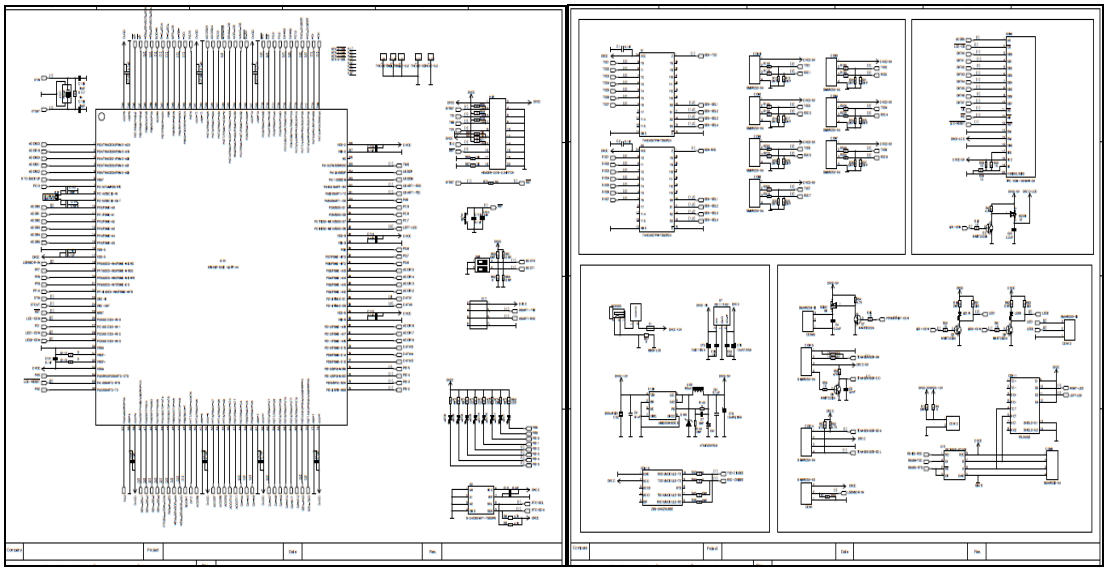
(1) Selection of environmental factors -> (2) Production of transmitter module -> (3) Configuration of dilution system ->(4) Purchasing and manufacturing of standard gas -> (5) Detection characteristic test

<Figure 1> Evaluation procedure of detection measurement of environmental factors

Final selection method of sensor was based on the sensors with higher correlation coefficient (R^2) due to correlation analysis between the correction value measured by application sensor according to the change in standard gas concentration and measured value based on official test method, with less interference from other gases, and less responsive to changes in temperature and humidity.

2) PCB design and development

The device consists of PCB and sensor, including parts such as MCU, wireless communication, wired communication, sensor, power supply, operating system, and LCD panel. PCB schematic of the device is shown in <Figure 2>.



<Figure 2> PCB schematic of the device

3) Wireless and wired data communication and storage systems

An integrated wireless measurement device was developed by combining the selected sensors. Wireless measurement device is the core technology of monitoring archives preservation environment, and a lightweight and wireless measurement device was developed as the power consumption was lowered by considering the space for multiple sensors and devices.

The operation program sends the measured results from real-time measurement device to the clients' PC through wireless transmission technology Zigbee (IEEE 802.15.4 communications

standard, 2.4GHz frequency band, 868/915MHZ, transmission distance of 150m, transmission speed of 20 ~ 250kbps, and real-time transmission cycle), and the clients' PC sends the data to the server via intranet.

4) Development of real-time monitoring system for preservation environment

The system device is easy to attach and detach for on-site practicality, and materials that can withstand external shocks were selected. The appearance was designed to be simple and that can be used in indoor environment as well.

Particularly, in terms of the device's structure, the illumination intensity, temperature, and humidity sensors were located at the top of the device according to the experiment. In other words, the power lamp was placed to the right of the device and illumination intensity sensor was placed to the left in order to minimize interaction between them.

The device is managed by the operating program of real-time monitoring system, and the program was designed to make appropriate responses to emergency situations and to be easily used by the manager. Real-time monitoring device for preservation environment is shown in <Figure 3>.

<Figure 3> Real-time monitoring system device for preservation environment

Key functions of the operating program include the following: communication set up, measuring device registration, environmental factors registration, risk classification system registration, inquiry, corrections, data charts and graphs output, data and risk level inquiry, administrator registration, sending administrator SMS, alarm, etc.

6. Conclusion

NAK developed a real-time monitoring tool for archives preservation environment based on USN.

The prototype has completed field application tests in archives, libraries, antique furniture showrooms, etc., and patent review is currently underway.

When state-owned patent technology transfer is implemented and the product is fully commercialized in the future, it is expected to be used widely in multi-use facilities in areas of large floating population and areas that require clean air such as hospitals, subway stations, etc. as well as archives management agencies, libraries, and museums. Large demand is especially expected from agencies without state-of-the-art preservation facilities.