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IOT APPLICATION ON REMOTE MONITORING AND CONTROL OF MUSEUM DISPLAY CABINET

Kai-Chao Yao[1], Wei-Tzer Huang[1], Chen-Yu Lo[1]
Li-Chiou Hsu[1] and Jiunn-Shean Chiang[2]

[1]Department of Industrial Education and Technology
National Changhua University of Education
No. 2, Shi-Da Road, Changhua City 50007, Taiwan
kcyao@cc.ncue.edu.tw

[2]Department of Mechanical Engineering
Hsiuping University of Science and Technology
No. 11, Gongye Road, Dali Dist., Taichung City 412-80, Taiwan

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Abstract. *As a social and cultural institution, museum has the role of ensuring social and cultural continuity and promoting social development. Its existence is definitely important and priceless. When the museum is in the process of exhibition, transport and storage of valuables require monitoring and control of temperature, humidity and vibration. In this research, we apply NI myRIO and LabVIEW to establishing valuables surveillance system including three-axis tilting state monitoring, temperture monitoring, humidity monitoring and real-time image monitoring, and also these measured data and control functions are built by LabVIEW for friendly interface. The remote wireless monitoring and control are achieved by Wi-Fi communication mode. Moreover, with multi-sensors, the whole structure forms an IoT application system. When the measured data is out of expectation, the system can alert the maintainer to ensure the valuables are deposited in the right environment.*
Keywords: MyRIO, IoT, Museum, LabVIEW

1. **Introduction.** Art and culture have always played an important role in human beings' lives. Over the centuries, hundreds of museums and art galleries have preserved our diverse cultural heritage and served as important sources of education and learning. How to protect these valuables is a very important issue to consider. Thanks to recent advances in miniaturization and lower cost of RFID, Bluetooth Low Energy, sensor networks, NFC, wireless communications technologies and applications, IoT is gradually acquiring an important role in several research fields. In the recent years, protecting ancient history articles also has turned out to be one of the most suitable domains in which such achievements can be profitably exploited, since it characterizes a domain where several aspects have to be considered at the same time: logistics, economy, tourism, entertainment, tutelage, and so on. Protecting ancient history articles can be considered as environment monitoring and control. In this paper, we focus specifically on designing an IoT architecture that is able to support the smartness of indoor cultural protection environments like museums or art exhibitions [1].

IoT embeds computer intelligence into home devices and provides the user with a convenient way to measure home conditions and monitor environment appliances. Cloud computing provides scalable computing and storage power for developing, maintaining, and running environment services. In addition, using cloud computing allows the user to access (monitor and/or control) deployed devices anytime and anywhere [2,3].

The Internet of things paradigm supports the transition from a closed world, in which an object is characterized by a descriptor, to an open world in which that object interacts with the surrounding environment, because it has become "intelligent". Accordingly, not only people will be connected to the Internet, objects such as cars, fridges, televisions, water management systems, buildings, and monuments will be connected as well. Combined with sensor technologies, this allows for remote management of the objects and remote monitoring of conditions and changes, which in the future might improve preservation, valorization and fruition of culture heritage [4-7].

LabVIEW is a data-flow graphical programming language (G-program) that plays an important task in the virtual instrument and control development. The vision of LabVIEW is to be a revolutionist solution for engineers and scientists, precipitating faster development time, lower costs and greater flexibility than traditional instrument and control [8].

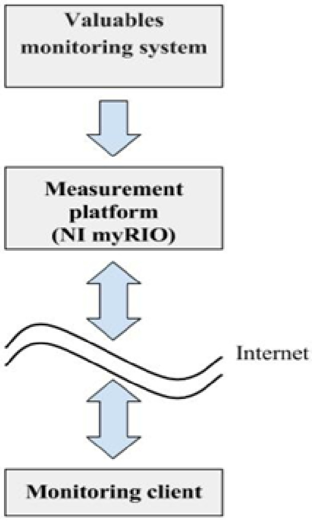


Figure 1. The system structure

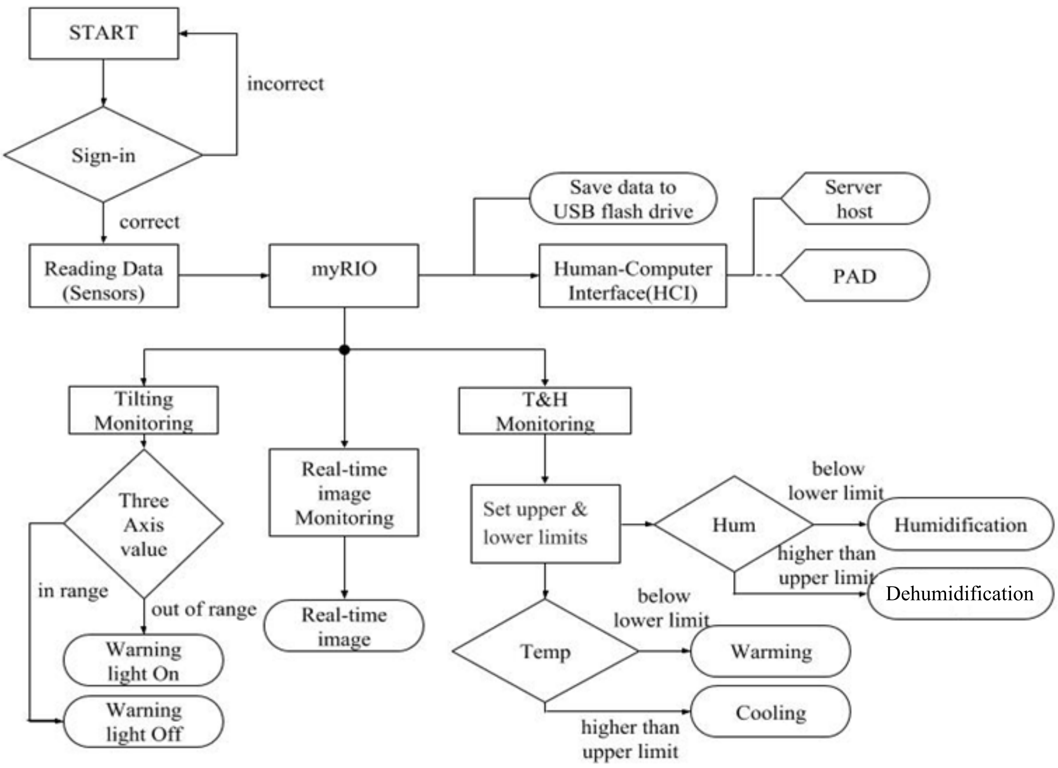
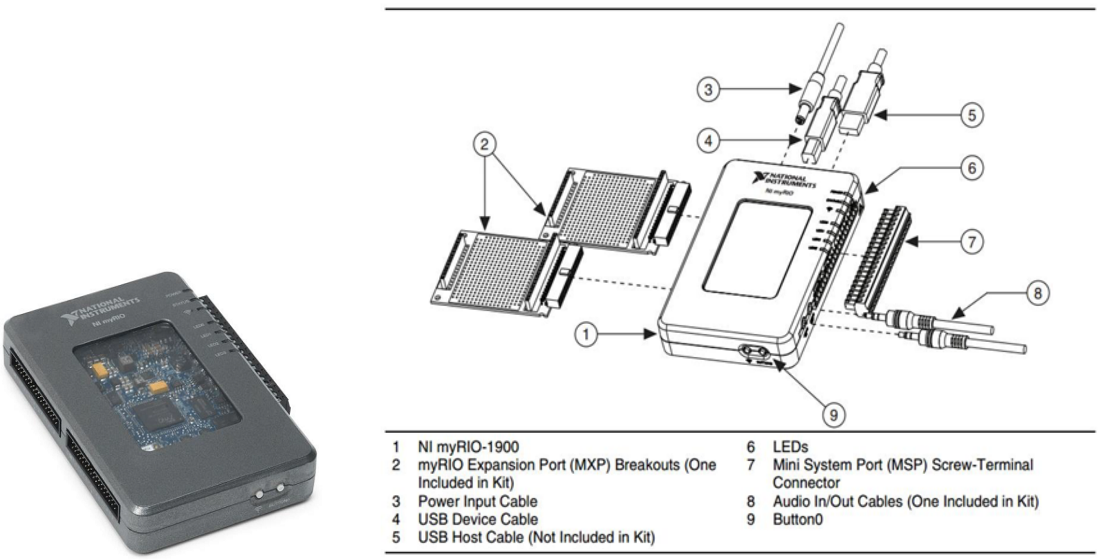


Figure 2. The monitoring and control flow of the system

2. **System Structure.** The system applies NI myRIO as embedded control system server and IoT technology to building an article protection system in museum. The software part uses LabVIEW program and Data Dashboard is used as a remote monitoring and control palette. The monitored data sensed by myRIO are sent to Data Dashboard for display and control. The system structure is showed as Figure 1. The monitoring clients include tilting status, temperature, humidity and real-time image. Figure 2 shows the monitoring and control flow of the system.

2.1. **Hardware part.** MyRIO is an embedded hardware device that places dual-core ARM® Cortex^{TM}-A9 real-time processing and Xilinx FPGA I/O. It has 28000 programmable logic units, 10 analog inputs, 6 analog outputs, 40 digital I/O channels and sound I/O channel; moreover, there are WIFI, three-axis accelerometer and display LEDs that are built inside. Figure 3(a) shows the outside look of NI myRIO and Figure 3(b) is the structure of NI myRIO.

Also, a tablet computer is used with the App, Data Dashboard for LabVIEW, to achieve remote monitoring and control. Figure 4 shows the screen of Data Dashboard for LabVIEW in a tablet.



(a) (b)

Figure 3. (a) The outside look of NI myRIO; (b) the structure of NI myRIO

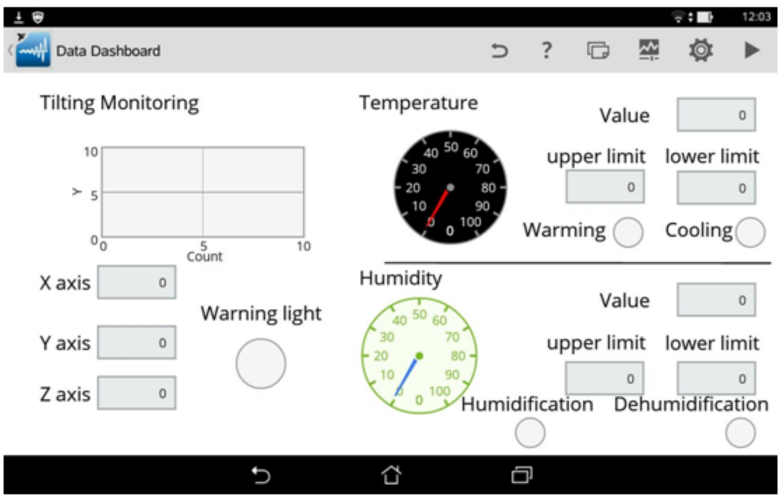


Figure 4. The screen of Data Dashboard for LabVIEW in a tablet

2.2. **Software part.** This study uses LabVIEW as software to design remote monitoring and control system for valuables in museum. This software can easily process numerical analysis, signal transformation, waveform display, equation calculation and so on. Moreover, its graphical language can replace the low-level programming language for achieving better performance and solving problems. Figure 5 shows the front panel of the system and every block inside the front panel is stated in main results.

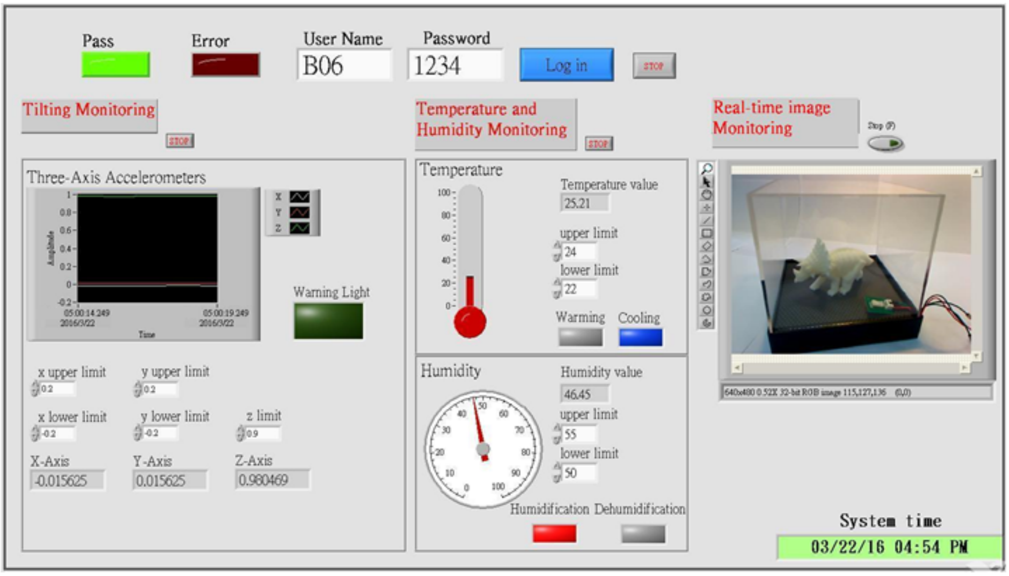
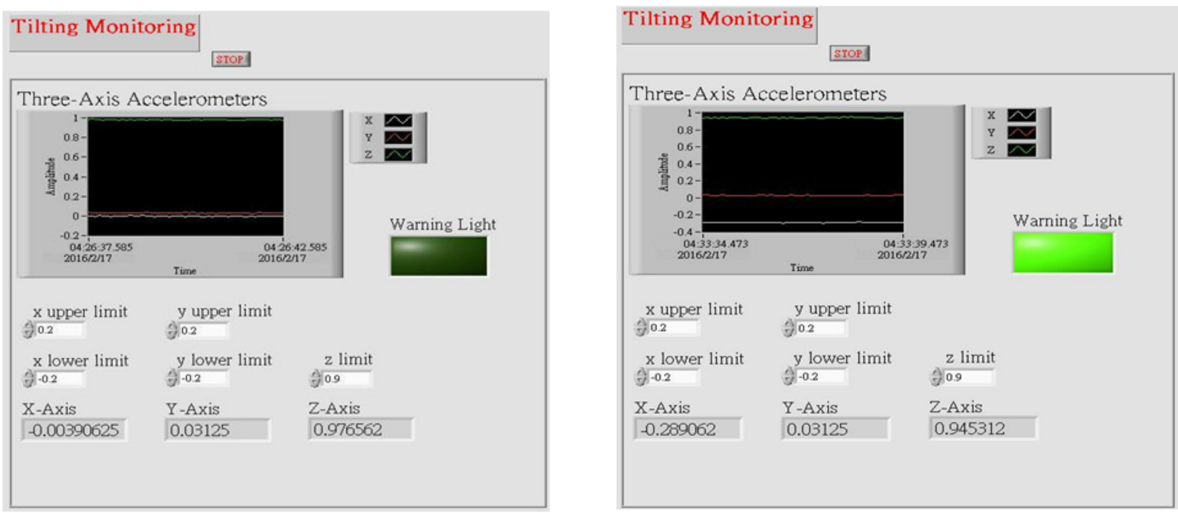


FIGURE 5. The entire front panel of the monitoring and control system

3. Main Results.

The designed monitoring and control functions are stated below.

3.1. **Sign-in function.** The sign-in function is designed by inputting the account number and password. If the input account number and password are incorrect, a small pop-out window will show a message for user to retry the login.



(a) (b)

FIGURE 6. (a) The tilting monitoring is normal; (b) the tilting value is over the X-axis tilting safe limit

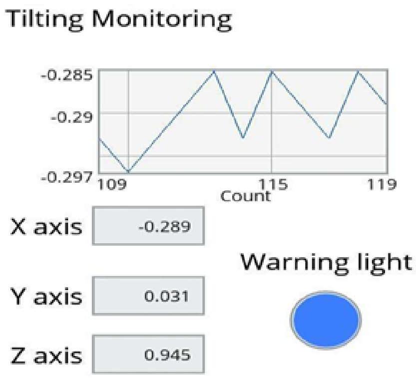


Figure 7. The display status of Figure 6(b) in remote tablet computer

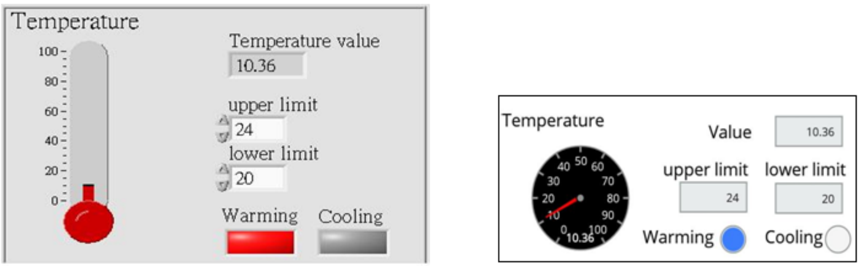
3.2. **Tilting monitoring and control.** Tilting monitoring function is designed by using the three-axis accelerometer inside myRIO. Also, by applying shared variables, the remote dashboard display and control are achieved. Figure 6(a) shows X, Y and Z axes are inside the tilting limits and Figure 6(b) shows the value of X-axis is over the tilting upper limit and the warning light is activated. Figure 7 shows the display status of Figure 6(b) in remote tablet computer.

3.3. **Temperature and humidity monitoring and control.** Culture relic and heritage require a steady temperature and humidity environment for reserving and displaying in museum. For example, the temperature and humidity to exhibit ancient painting are $20 \sim 24$°C and $50 \sim 55$% in Paris Museum. HSM-20G is applied in this project and the data sheet is shown in Table 1.

Figure 8 shows the displays of computer and remote tablet detecting the temperature is 10.36 and the lower limit is 20°C; therefore, the warming system and warning light

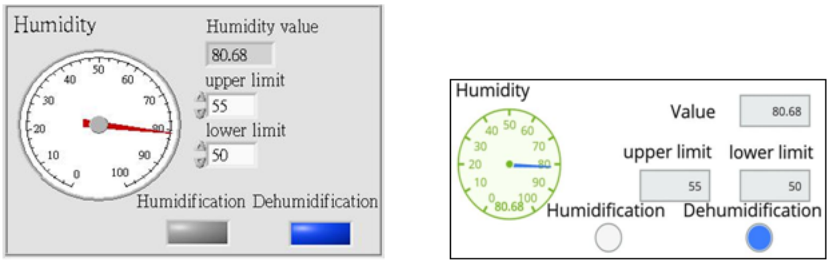
Table 1. The data sheet of HSM-20G

Characteristics	HSM-20G
Input Voltage Range	DC5.0 $\pm$ 0.2V
Output Voltage Range	DC1.0 $\sim$ 3.0V
Measurement Accuracy	$\pm$5%RH
Operating Current	2mA
Operating RH Range	20% $\sim$ 95%RH
Temperature Range Operating	0° $\sim$ 50°C
Hysteresis (RH@25°C)	MAX 2%RH
Long Term Stability (typical drift per year)	$\pm$1.5%/year



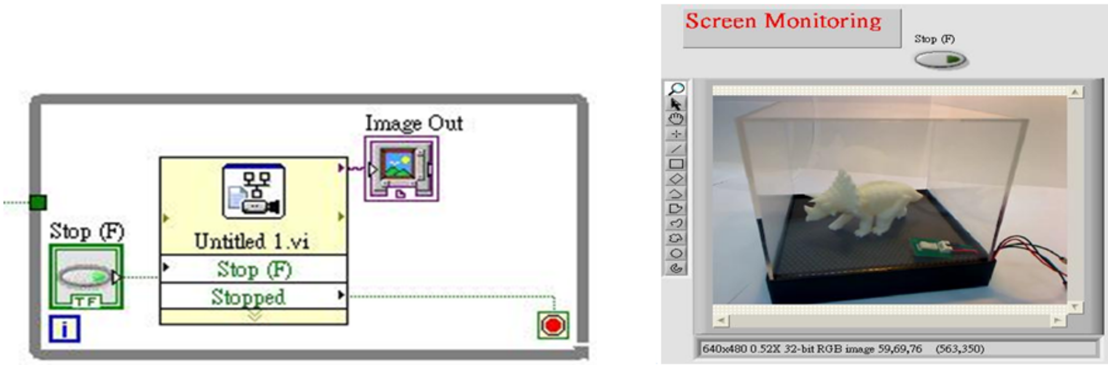
(a) (b)

Figure 8. (a) The temperature display of computer; (b) the temperature display of the tablet



(a) (b)

Figure 9. (a) The humidity display of computer; (b) the humidity display of the tablet



(a) (b)

Figure 10. (a) The block diagram part of the real-time image monitoring function; (b) the real-time image monitoring

are turned on. Figure 9 shows the display of computer and remote tablet detecting the humidity is 80.68% and the upper limit is 55%; therefore, the dehumidification system and warning light are turned on.

3.4. **The real-time image monitoring.** Figure 10 shows the real-time image monitoring status by connecting USB Web Cam after program design. Figure 10(a) is the block diagram part of the real-time image monitoring function and Figure 10(b) is the real-time image monitoring.

4. **Conclusion.** In this project, NI myRIO and LabVIEW are applied to designing and constructing a local and remote monitoring and control system structure for protecting precious articles in museum exhibition by the concept of IoT. The functions include sign-in protection, titling detection, temperature detection, humidity detection and real-time image monitoring. The corresponding devices or systems will be also activated such as cooling system, warming system, warning lights and warning sound. The detected instant data will be also transmitted to remote tablet and displayed. Due to the compact size of myRIO, the system can be easily deployed into the exiting display cabinet, even in transport and storage, due to the fact that the system has the remote function providing more convenient monitoring and control in various situations.

IoT technology innovates the current industry in many ways. Computer and network create lots of new thinking and solution never done before, especially in the IoT field of research. In this research, NI myRIO and LabVIEW are integrated, this design and methods can also apply to other environments for monitoring and control, such as home and factory.

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