Development of a Web-Based Greenhouse Monitoring System Using a Field Server

Lee, Kang Oh
Foodsafety team, Korea Information Center for Agriculture, Forestry and Fisheries

Bae, Yeonghwan
Department of Industrial Machinery Engineering, College of Bio-Industry Science, Sunchon National University

Oh, Minsug
Department of Industrial Machinery Engineering, College of Bio-Industry Science, Sunchon National University

Nakaji, Kei
Laboratory of Agricultural Ecology, Division of Agronomy & Environmental Sciences, Department of Agro-environmental Sciences, Faculty of Agriculture, Kyushu University

https://doi.org/10.5109/19537

出版情報：九州大学大学院農学研究院紀要. 56 (1), pp.103-108, 2011-02. Faculty of Agriculture, Kyushu University
バージョン：

J. Fac. Agr., Kyushu Univ., **56** (1), 103–108 (2011)

Development of a Web–Based Greenhouse Monitoring System Using a Field Server

Kang Oh LEE[1], Yeonghwan BAE[2]*, Minsug OH[2] and Kei NAKAJI[3]

[1]Foodsafety team, Korea Information Center for Agriculture, Forestry and Fisheries, Korea
[2]Department of Industrial Machinery Engineering, College of Bio–Industry Science, Sunchon National University, Korea
[3]Laboratory of Agricultural Ecology, Division of Agronomy & Environmental Sciences, Department of Agro–environmental Sciences, Faculty of Agriculture, Kyushu University, Fukuoka 811–2307, Japan
(*Received October 29, 2010 and accepted November 8, 2010*)

This study was conducted to develop a web–based field monitoring system which can observe the agricultural weather information, crop images, and field operations in real time through a commercial field server in a greenhouse growing *Shiranui*. A soil sensor was added to the existing sensor system of the field server, and the field server was mounted on top of a newly developed up and down position–control stand to monitor crop growth in detail. The up and down control can be performed by switch operations at the site or a distance control, that is, the height can be adjusted through the internet, thus the crop growth images could be monitored in more detail. In addition, the system was designed and established with considerations for installing multiple field servers and extensibility toward several places. Therefore, it is expected to improve agricultural productivity and to provide the most suitable growth environment through this developed system.

INTRODUCTION

Recently, interest for safe foods is rapidly growing due to improved standard of living and the priority for health. Because the cases for domestic and international food accidents are increasing, customers ask for various needs in the safety of the agricultural products in production, processing, and distribution (CRIC, 2009). With growing interests for the GAP certification and the traceability system in the safety of agricultural products, particularly in production, many studies have been conducted to apply information technology in agriculture. Especially, a ubiquitous information technology (u–IT) to monitor agricultural production environments is rapidly spreading by using a sensor network such as RFID and USN which have been especially used in industry. An automated irrigation system (Kim *et al*., 2006) and a greenhouse control system (Gonda and Cugnasca, 2006) are illustrative examples.

A recently developed field server can easily collect field conditions and growth images through the internet and Web–browser in real time as well as control greenhouse facilities (Hirafuji and Fukatsu, 2003). Pavan *et al*. (2006) used the field server technology to predict diseases and insects in wheat and apple by integrating weather information and crop growth conditions. Hashimoto *et al*. (2006) controlled the growth environments by using tomato colors complied through the field server. In Japan, 'Earth Observation Project' has been conducted to monitor soil environments extensively by installing many field servers across Asia and America since 2002.

Several kinds of field server have been developed and used in crop fields to acquire information for growth conditions and growth monitoring. The field server is a kind of sensor networks which can be installed in greenhouse and fields. It is composed of several weather sensors, CCD camera, and wire or wireless internet router. Therefore, it is expected to improve crop productivity and safety in agricultural products by using field servers which can monitor crop growth conditions and history in a distance and can collect growth information to control environments.

We developed a real–time greenhouse monitoring system which can provide environmental conditions and distance control through the Internet. The system using a commercialized field server was installed in a greenhouse growing *Shiranui* ((*Citrus unshiu* × *C. sinensis*) × *C. reticulata*) in Suncheon, Korea to monitor weather conditions, crop images, field operations, etc.

MATERIALS AND METHODS

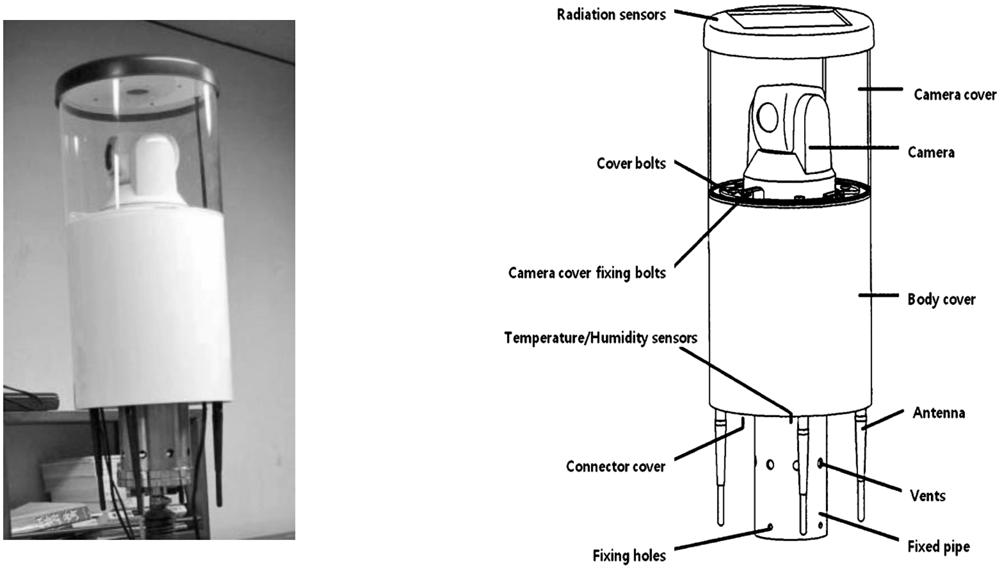
1. Field server description

The field server (E–lab Experience Inc., Japan) in this study is composed of a web–camera, weather sensor, and communication facility (Fig. 1). The field sever consists of a field server engine with a computer for measurement and control and a wire or wireless LAN connecting board in the communication part. Due to the advanced technology, wireless LAN with high proficiency and low price can be used in the communication part. A field server engine internally contains the web–server

[1] Foodsafety team, Korea Information Center for Agriculture, Forestry and Fisheries, Korea
[2] Department of Industrial Machinery Engineering, College of Bio–Industry Science, Sunchon National University, Korea
[3] Laboratory of Agricultural Ecology, Agronomy & Environmental Sciences, Department of Agro–environmental Sciences, Faculty of Agriculture, Kyushu University, Fukuoka 811–2307, Japan
* Corresponding author (E–mail: yhbae@sunchon.ac.kr)

for measuring and distant controlling and input and output HTML data to be connected to the web–browser in PC. Moreover, the server has functions to integrate data from sensors at the analog port and to input and output control signals, internal memory to store data or programs, and a DDS (Direct Digital Synthesizer) which can measure frequency such as impedance. This field server was designed to measure temperature, moisture, and solar radiation in the field, to perform distance control or environmental control by connecting facilities such as irrigator or heater to output control, or to monitor soil moisture or electric conductivity (EC) easily.

The field server contains four weather sensors: temperature, humidity, radiation, and soil sensor. These sensors measure weather inside greenhouse in real time, and these data are stored and can be used later. The web–camera with 300,000 pixels provides the crop growth in real time, so anyone can check crop growth anytime.



(a) Field server used in this study (b) Field server parts

Fig. 1. Photograph of a field server and name of the parts.

Table 1. Specifications of the field server

configuration			Property
Sensor Network Board	Maker and model		Elab experience, FS–(H8S)Eng02
	Communication protocol		HTTP, TCP/IP
	Data output format		Text (HTML)
	Sensor input	Number of external channels	4 CHs (CH1, CH2, CH3, CH4)
		Number of internal channels	4 CHs (CH5, CH6, CH7, CH8)
		Power	CH1and CH2: 2.5 V, Others: 5 V
		Resolution	3.2 mV (LSB)
		Range of measurement	100 mV~2.7 V
		Refresh interval	Renewal in every 30 seconds
	Contact input	Number of channels and voltage	4 CHs, 15 V/20 mA
	Contact output	Number of channels and voltage	4 CHs, AC 20 V/1 A
	D–SUB9 serial port		RS232 (19,200 bps)
	5pin, 3pin serial port		for VAISALA weather sensors and maintenance
Camera	Maker and model		Toshiba, IKWB21
	Maximum image size		1280×960
	Angle of rotation		−175° ~ + 175°
	Focus		Automatically controlled
Format of wireless network			ThinkTube EMB503, Wireless LAN (2.4 GHz)

Table 2. Composition of environmental measurement sensors in the field server

Channel	Sensor	Specification
CH4	Soil temperature (added)	National Semiconductor LM35 Range: –20 ˚C~ 60 ˚C Conversion: Soil temperature = 0.3223 × measured value – 99.383
CH5	Air temperature	National Semiconductor LM35 Range: –10 ˚C ~ 50 ˚C Conversion: Temperature = 0.3223 × measured value – 99.383
CH6	Humidity	TDK CHS–UPS(polymer sensor, resistive), Range: 5% RH ~ 95% RH Conversion: RH = 0.3709 × measured value + 3.7019
CH7	Radiation	Photovoltaic Range: 65 W/m^2~ 2,500 W/m^2 Conversion: Radiation= measured value –12

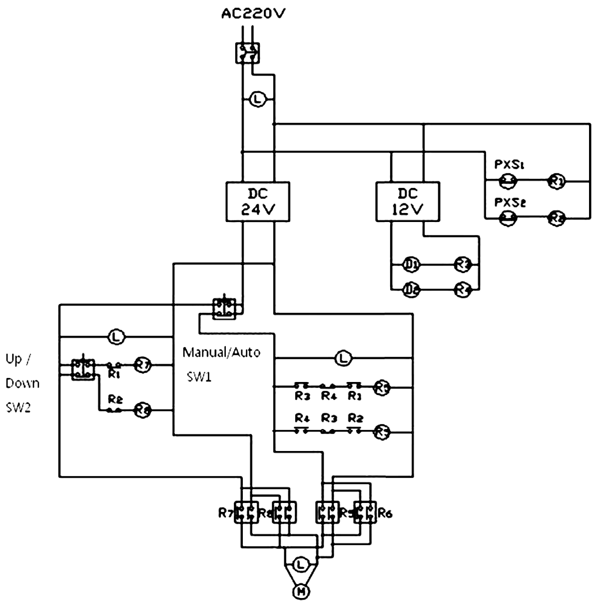


Fig. 2. Circuit diagram of the up/down position controller for the mounting stand.

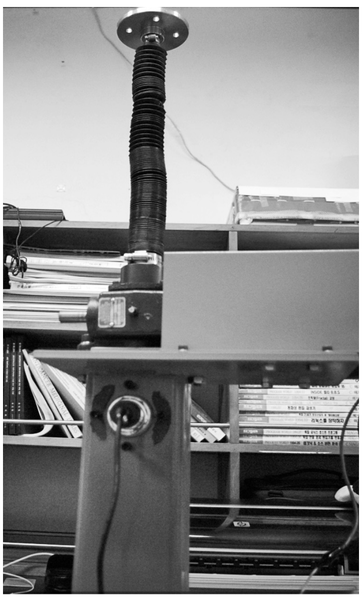


Fig. 3. Photograph of the up/down position controller and a fixing frame.

(a) Exterior (b) Interior

Fig. 4. Photographs of the greenhouse used in this study (*Shiranui* farm, Suncheon, Korea).

Details of the field sever are described in Table 1. In this study, the field server collected weather data in a greenhouse through temperature (CH5), humidity (CH6), and radiation (CH7) sensors internally installed and an external soil temperature sensor purchased separately (Table 2).

2. Development of a facility to control the vertical position of the field server

When the field server was installed in the greenhouse to measure environmental variables, it is possible to control the angle of rotation (–175°~175°) for the image, but not possible to control the up and down position. Therefore, the up and down position controller was developed and installed for controlling the vertical position of the field server. The circuit diagram of the field server for the up and down position controller on the stand shows the possibility for the on–site and distance control (Fig. 2). Furthermore, a jackscrew and a DC motor were additionally built in to the stand of the field server for the up and down position control (Fig. 3).

3. Field (Greenhouse) description

The study site is located in Suncheon, Korea. The field server system was installed at the *Shiranui* greenhouse in 2009 May. The farmers at the farm have 9 years of experience for growing *Shiranui*. The *Shiranui* greenhouse is a standard greenhouse as a 1–2W type. There are two greenhouses, and the size of each of them is 1322 m^2 (Fig. 4). When they introduced *Shiranui* seedlings from Jeju Island at the first time, it was very difficult to establish the farm due to the lack of skills.

However, they now produce high quality of *Shiranui* 5,000 boxes (3 kg/box) annually from two greenhouses, and earn more than 150 million wons per year after acquiring know–how for *Shiranui* growth.

RESULTS

1. Development of an internet–based greenhouse monitoring system

Fig. 5 shows a diagram for the web–monitoring system where anyone can observe measurements from the sensors on the field server and the greenhouse environment by the web–camera through the internet. Measured values at the field server in the greenhouse were transferred from the connected local computer to the web–server through the internet. Any user can freely acquire the information for the greenhouse environments as well as crop growth image in a distance through the internet homepage.

The field monitoring system using a field server was developed by using free web hosting. The free web hosting has merits that a web based administrator function and application programs are provided and that a web monitoring system can economically be developed. A PHP based Zeroboard XE 1.5 application was used, and database was developed by MY SQL 5.0.45–10 g. Although only one field server was used in this study, the web–based real time field monitoring system was designed and developed with considerations for multiple field server installation and information connection across several sites.

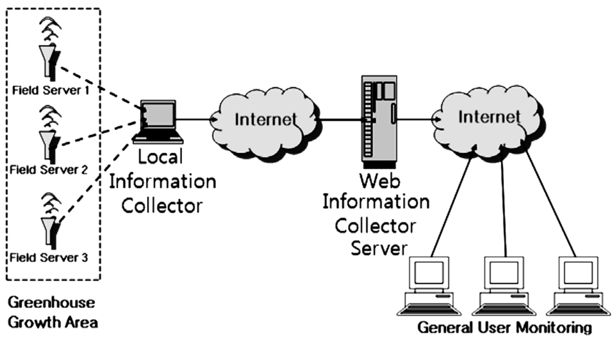


Fig. 5. Description of the greenhouse monitoring system in a distance by using field severs.

2. Collection of weather information and program development for the DB

This study particularly developed a program by using Visual Basic 5.0, PHP4.0, JAVA, etc. to collect and store the field data, and then to transfer it to the data collection server in a distance although there is software (Point VIEW) provided from the producer of the field server. These processes are needed for people to use and check the collected field data from the internet.

Data collection and storage program at each local field server in the greenhouse consists of a folder storing all modules used in the data collection program, a folder for upgrading programs, a backup folder for the changed files, a storage of all log files made in an information collector, environment setting files for the information collector, etc. The program was developed by considering future extensibility at maximum because it is possible to set up the address of the field server and frequency of data collection from the environment setting files.

Weather data was collected from the sensors and stored after program running every 30 minutes in this study, but the frequency can be modified according to situation. Stored weather conditions in greenhouse are transferred to and stored in the web server so that users can easily access the information real time through the internet web site. Fig. 6 is a flow chart of the program which collects data from the local computer at the farm having field server and transfers them to the web information collection server.

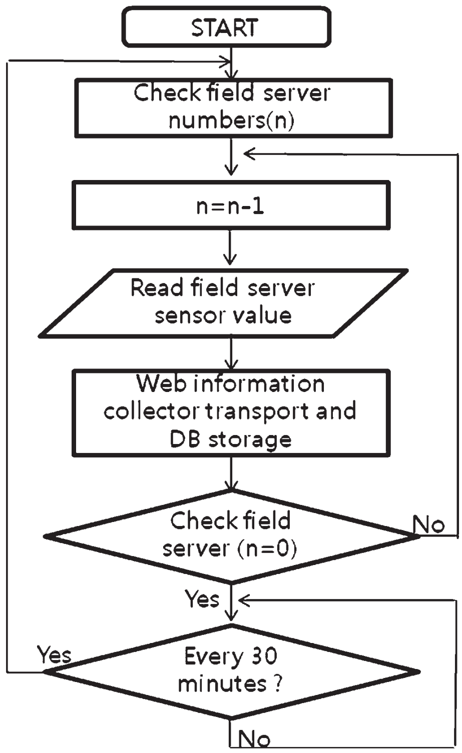


Fig. 6. Flow chart of weather data collection and DB management by a field server.

3. Installation of a field server in greenhouse

The field server installed in the *Shiranui* greenhouse collects weather information such as air temperature, humidity, radiation, and soil temperature which is transferred and stored in the internet web server through the local information collector network (ADSL). The crop growth image is transferred and stored in the internet web server by the FTP protocol (Fig. 7). It is expected that the agricultural productivity information collected by the field server can be utilized easily in the internet. It is possible to do distance control for the greenhouse facilities based on collected weather information, and time, labor, and cost can be reduced by decisions made on the basis of scientific information. Although distance control was limited to the location control of the field

(a) Installation of field server in greenhouse (b) local PC for collecting greenhouse information

Fig. 7. Photographs of installation of field server and local PC in greenhouse.

server in this study, there is a potential to extend distance control to several environmental facilities.

The crop growth environment and field operations are easily monitored through the web camera (Toshiba IKWB21, Japan) with high resolution (1280×960) and wide angle of rotation (−175°~+175°). Growers can get consulting from specialists in a distance or discuss with relevant farmers by using the images for the occurrences of diseases and insects during growth which are obtained by a high resolution video and zoom–in function. However, the web camera can rotate to right and left but not up and down movement because the field server is fixed to the supporting pole.

In this study, to compensate this demerit, a field server mounting stand was transformed by a jackscrew for up and down vertical position, and the position could be controlled either on–site or in a distance through the internet. The web camera can be positioned from 150 cm to 300 cm above ground. This flexible movement of the field server provided various views of spots so that growing crops in greenhouse can be observed in detail. The up and down positioning facility can be controlled either directly by the control box in greenhouse or by the on/off function of the field server in the internet. The up movement from the lowest point to the maximum took 2 minutes and 30 seconds, and it took the equivalent time for the down movement (Fig. 8)

(a) Control screen for up movement of the stand (b) Field server at the highest position

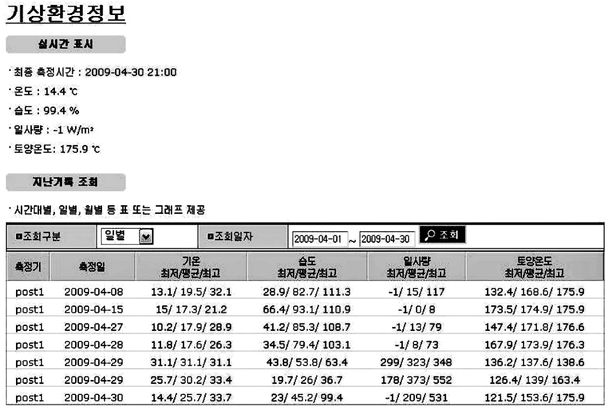
Fig. 8. Control screen and the field server at the highest position.

4. Applications of web–based greenhouse monitoring system

Weather information and crop growth images in the greenhouse with a field server are provided real–time through the internet. Available weather information includes air temperature, humidity, radiation and soil temperature, and statistics for those data each month, day, and time are provided as tables or graph (Fig. 9).

Crop growth video provides the present image of the crop real time and the past images during growth. When the diseases or insects occur, the high resolution images gathered from the crop growth video can be used in consulting with external specialists or farmers in related fields.

It is expected to develop a linkage system between this monitoring system and electronic commerce so that customers can purchase agricultural products which have been monitored through a field server.



측정기	측정일	기온 최저/평균/최고	습도 최저/평균/최고	일사량 최저/평균/최고	토양온도 최저/평균/최고
post1	2009-04-08	13.1/ 19.5/ 32.1	28.9/ 82.7/ 111.3	-1/ 15/ 117	132.4/ 168.6/ 175.9
post1	2009-04-15	15/ 17.3/ 21.2	66.4/ 93.1/ 110.9	-1/ 0/ 8	173.5/ 174.9/ 175.9
post1	2009-04-27	10.2/ 17.9/ 28.9	41.2/ 85.3/ 108.7	-1/ 13/ 79	147.4/ 171.8/ 176.6
post1	2009-04-28	11.8/ 17.6/ 26.3	34.5/ 79.4/ 103.1	-1/ 8/ 73	167.9/ 173.9/ 176.3
post1	2009-04-29	31.1/ 31.1/ 31.1	43.8/ 53.8/ 63.4	299/ 323/ 348	136.2/ 137.6/ 138.6
post1	2009-04-29	25.7/ 30.2/ 33.4	19.7/ 26/ 36.7	178/ 373/ 552	126.4/ 139/ 163.4
post1	2009-04-30	14.4/ 25.7/ 33.7	23/ 45.2/ 99.4	-1/ 209/ 531	121.5/ 153.6/ 175.9

Fig. 9. Main screen on a greenhouse monitoring system with distance control.

Fig.10. Photograph of image monitoring and camera control screens through internet.

ACKNOWLEDGMENT

This paper was supported in part by Sunchon National University Research Fund in 2008.

CONCLUSION AND DISCUSSION

A system to monitor weather information and crop (*Shiranui*) growth images through a field server in a greenhouse was developed. A newly developed up and down position controller for the mounting stand of the field server could provide detail and extensive images of the crops during growth.

Weather information collected by the field monitoring system can help farmers establish the best growing conditions for the crops through distance control for several facilities in the greenhouse. High resolution growth images will provide opportunities for farmers to get opinions for diseases and insects from specialists and to communicate with agricultural organizations or farmers working in the related field. Improved productivity is expected through active interactions supported by the monitoring system. Moreover, visual information for the *Shiranui* growth and descriptions for work specification through the internet can make customers trust the safety for agricultural products. In the near future, we are going to develop a system to link the greenhouse managements by several field servers in greenhouse and the internet shopping.

REFERENCES

CRIC, 2009, National Food Safety Survey, Research Reports

Hirafuji, M. and T. Fukatsu, 2003 Server development field for field monitoring, Agricultural information research **12**(1), pp. 1–12

Fukatsu, T., M. Hirafuji, and T. Kiura, 2006 A distributed agent system for managing a web–based sensor network with field servers, Computers in Agriculture and Natural Resources, 4th World Congress Conference, Proceedings of the 24–26 July (Orlando, Florida USA), pp. 223–228

Gonda, L. and C. E. Cugnasca, 2006 A proposal of greenhouse control using wireless sensor networks. Computers in Agriculture and Natural Resources, 4th World Congress Conference, Proceedings of the 24–26 July 2006 (Orlando, Florida USA), pp. 229–233

Hashimoto, A., K. Yasui, M. Takahashi, S. Yonekura, T. Hirozumi, T. Mishima, R. Ito, K.–I. Suehara, T. Kameoka, 2006 Remote monitoring of color of agricultural products in the field using a digital camera and the field server. Computers in Agriculture and Natural Resources, 4th World Congress Conference, Proceedings of the 24–26 July (Orlando, Florida USA), pp. 66–71

Kim, Y. , R. G. Evans, W. M. Iversen, F. J. Pierce, and J. L. Chavez, 2006 Software design for wireless in–field sensor–based irrigation management. ASABE Paper No. 063074. St. Joseph, Michigan, USA.

Pavan, W., J. M. C. Fenandes, R. M V. Sanhueza, E. D. Ponte, C. R. Cervi, and J. Dalbosco, 2006 Web–based system to true–forcast disease edidemics – Sisalert, Computers in Agriculture and Natural Resources, 4th World Congress Conference, Proceedings of the 24–26 July (Orlando, Florida USA), pp. 655–659