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Article *in* International Agricultural Engineering Journal · June 2013

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Abstract: This research aimed to design a control system for greenhouse over internet so that its monitoring and control can be remotely done. The designed system consists of hardware (sensors, microcontroller, switches, computer, webcam, actuators) and software (acquisition and control). System's performance was tested by installing it in a model greenhouse equipped with actuators (fans, pump, sprayer, mechanical shading, and camera rotator) and connecting it to a computer network. Hydroponic lettuce (*Lactuca sativa*) cultivation was monitored during its entire growing period while microclimatic parameters including temperature, humidity, light, and moisture content were controlled under three operating modes (manual, automatic, and timer). Fan, pump, and sprayer were controlled using switches to ensure that the microclimatic parameters are maintained within desired range. Mechanical shading and camera rotator were controlled proportionally using servo motor, driven by PWM signals. Performance of the system under three operating modes was evaluated and compared. The results indicate that controlling four parameters including temperature, humidity, light, and moisture content can be successfully done remotely via internet using Remote Desktop®. Surveillance unit provides pictures of plant growth that offers additional information to be considered for making a control decision.

Keywords: greenhouse control system, internet, microclimate control, remote monitoring and control

Citation: Marhaenanto, B., P. Soni, and V. M. Salokhe. Development of an internet-based greenhouse control system. International Agricultural Engineering Journal, 2013; 22(2): 72－83.

1 Introduction

A greenhouse is structure covered by transparent material in which commercial crops are grown (Rodríguez et al., 2010). It creates a microclimate which can be controlled to meet the needs of crops inside. An adequate greenhouse climate control can also reduce risks of diseases infection with minimum chemical application (Tantau and Lange, 2003; Salokhe et al., 2005a; Soni et al., 2005).

Control of temperature in a greenhouse has been designed and investigated by several researchers (Arvanitis et al., 2000; Coelho et al., 2005; El Ghoumari et al., 2005; Bennis et al., 2008). In subtropical countries where temperature is mostly cool, greenhouse effect is very useful to trap heat energy from the sun. If the heat energy is not sufficient, heater is needed. Conversely, in tropical region, greenhouse effect will raise temperature, which needs to be controlled, so that it does not exceed the value of crop's requirement. It uses cooling system such as fans, natural ventilation, cooling pad, and fogging (Abdel-Ghany and Kozai, 2006; Salokhe et al., 2005b; Soni et al., 2005b).

On the other hand, as an insulated space, greenhouse holds unfavorable levels of humidity that is harmful for plants. It is affected by many factors including temperature, respiration rate, and light. Humidity can be controlled using humidifier (increasing) or dehumidifier (decreasing). Perret et al. (2005) developed humidity

Received date: 2013-03-15 **Accepted date:** 2013-06-05

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controller in a Quonset greenhouse using moveable evaporative cooling and condenser as humidifier-dehumidifier. Four types of dehumidification are described (Campen et al., 2003) including natural ventilation, condensation on a cold surface, forced ventilation, and hygroscopic material.

Shading is part of greenhouse structure which helps to reduce energy load during sunny condition. It works by covering the area from high intensity of solar radiation with shading materials such as nets, curtains, and blade louvers. García et al. (2011) concluded that mobile shading and fogging systems are appropriate cooling methods in Mediterranean greenhouses.

Equipment in greenhouses which are used for controlling its microclimate are called as actuators in terms of control system. Onwubolu (2005) defined actuators as devices that are used to produce motion or action, such as linear motion or angular motion. Recently greenhouse actuators are electrically operated and driven by switches (ON/OFF) such as fans, pumps/valves, motors, lamps, heater, and cooling pad. Some actuators may operate with proportional control such as mechanical shading and opening level of ventilation which are driven by servo motor. Control of actuator can be done in several modes such as manual, timer, or automatic modes.

Manual control requires an operator to switch the actuator on/off or turning a lever/potentiometer to open/close at such level. It is based on information received from operator’s senses (eyes, ears, skin), their knowledge and experiences. Timer is used when actuators are operated in certain timing order or scheduled. It is an open loop control which does not consider the level of controlled parameter. The third mode is automatic control (close loop). It needs information of parameters which can be manipulated to obtain control action based on desired setting point. Control unit can be developed using simple electronic circuits, or the complex circuits which involves microcontroller and even computer system (mechatronics). Dorf and Bishop (2008) described elements of mechatronic system including (a) physical modeling, (b) sensors and actuators, (c) signals and system, (d) computers and logics, and (e) software and data acquisition.

Computer-based instrumentation and control of greenhouses has been attempted since long. Marhaenanto and Singh (2002) developed an environment controller for greenhouse with computer interface using PPI-8255 which included temperature and humidity. Omid (2004) used microcontroller through a serial interface to a PC for controlling temperature and humidity in greenhouses. Furthermore, Omid and Shafaei (2005) investigated the changes of temperature and humidity inside greenhouse using software composed in Visual Basic®. These computer-based systems still had “stand-alone” mode of operation although it has potential capabilities for remote operation using computer network such as intranet and internet.

In the era of advanced information technology, a term recently introduced is “Internet of Things” (IOT) to describe several things or objects which are able to communicate with each other to reach common goals (Atzori et al., 2010). This includes sensors, actuators, tags, RFID (Radio-Frequency Identification), and others. Furthermore, Miorandi et al. (2012) described an overview of the key issues related to the development of IOT applications. They have identified a number of research challenges which are expected to become major research attraction in the coming years. Applications of the IOT include but are not limited to smart homes/smart buildings, smart cities, environmental monitoring, health-care, smart business/inventory and product management, and security and surveillance.

The controlled environment agriculture system aims to configure the microclimate as plant’s need on a regular basis in order to increase productivity and quality. Microclimatic parameters (temperature, light, and humidity), and water/nutrition requirement needed to be frequently monitored along with some visual observation. Unskilled agricultural laborers who do not have the capability of decision-making on controlling the system require the owners should keep in constant touch with their plants.

Nonetheless, the conventional control (based on conventional decision-making) may make errors which are caused by obvious limitation such as miscommunication, wrong perception, time delay, and many others related to the human limitations. Therefore, to minimize these problems, it can be done by telemetry and remote control system which utilizes available and popular technologies of today such as smart-phone and the internet. Application of IOT in greenhouses may increase maneuverability of the controlled agriculture operation.

From the above-mentioned challenges and opportunities, this study developed its base. The main objective of this study was to develop greenhouse control system which integrates four important microclimatic parameters including temperature, humidity, light, and water level with remote interface over internet. The system is also equipped with camera (webcam) for visual monitoring and remote surveillance. Material, tools, and methods are selected based on their availability in the local market, cost effectiveness, and ease in fabrication.

2 Material and methods

A greenhouse control system refers to an agricultural greenhouse which is capable to maintain a favorable climate for plants through control system that employs sensors, signal processor, and actuators. The basic concept of IOT is connecting sensors and actuators to the global network. The easy way to implement this concept is making computer-connected devices via an interface. Connection to the network is provided by computer using appropriate operating system (OS) and software. This study can be explained into three steps including: (i) design of control system, (ii) installing control system in a model greenhouse, and (iii) performance test of control system.

2.1 Design of control system

Design of the control system was based on a computer-based measurement and control which uses a personal computer (PC) as brain of the system. Special programs were composed using Visual Basic®. Functions of programs included measurement of microclimatic parameters, control of actuators, and visual monitor with surveillance camera. The PC was connected to the network using Remote Desktop®. Another computer accessed it remotely via internet to operate the system.

Figure 1 shows the block diagram of the system. Sensors, actuators, and webcam are placed inside greenhouse. Sensors include temperature sensor, humidity sensor, light sensor, and water probes. Actuators consist of fans, water pump, sprayer pump, lamp, and two servo motors for mechanical shading and webcam rotator. Data acquisition and Switch Control are microcontroller boards as serial interfaces to computer unit (Desktop CPU) through COM ports. OS/Program is operating system and software which handles operation of the system. The CPU is connected to the global network using available internet connection provided by the ISP. Remote computer and smart phone are devices used as terminal of remote interface.

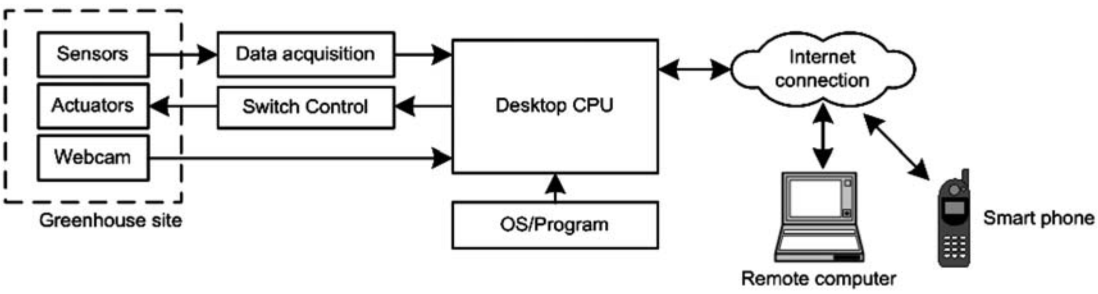


Figure 1 Block diagram of greenhouse control system over internet

2.2 Hardware

Hardware consists of sensors, microcontroller (MCU), and CPU. There were four sensors used in the system. Sensor IC LM35® (National Semiconductor, USA) was used for temperature with linear conversion factor (10 mV/C). Relative humidity (RH) was detected using humidity sensor type HSM-20G® (Yidong Industrial Co. Ltd., China), having detection range of 20% – 95% RH. Light Dependent Resistor (LDR) was used to detect light intensity; increased illumination causes decreased resistance of LDR. Soil moisture content was sensed by assembling two copper wires as probes.

Signal conditioning was used for matching the output of sensors with the analog input of microcontroller. Output of LM35 was within the range of 0 – 500 mV (0 – 50°C) and HSM-20G was 1000-3000 mV (22% – 95%) as specified by manufacturer. LDR and metal probes were based on resistance changes which are converted using voltage divider circuit. On the other hand, analog input of microcontroller was set internally 0 – 2.56 V.

MCU circuit includes two units; one for data acquisition (input) and the other for switch control (output). It uses ATMega8® (Atmel, USA), a low cost MCU with specifications including 8 KB of programmable flash memory, 1KB of SRAM, 512K EEPROM, six channels 10-bit A/D converter, and standard serial communication (Atmel, 2010).

Operation of the MCU is based on a program stored in memory. The program was composed in BASCOM-AVR® (MSC Electronic, Germany). Program was initialized with configuration of the MCU such as type, crystal frequency, ADC, and baud rate (for serial communication). Next sequences of the program were: generating a value 0-7 consecutively on PORTB (PB2, PB1, PB0) as channel selection of multiplexer; then reading ADC's output and sending the result to serial port followed by delimiter "/". By this operation, MCU continuously sends ADC's output (value in between 0-1023, as capacity of 10 bit ADC) consecutively from input channel 0 to channel 7 (T1, T2, RH1, RH2, L1, L2, MC1, MC2).

Second MCU is used to control electronic switches (relays) and to generate PWM (Pulse Width Modulator) signals based on received codes from computer (PC) via serial port. It provided eight relays and two PWMs. Unique codes are selected in order to distinguish between PC and MCU. Codes for relays consist of relay's number (0-7) and status (0-1); PWM codes consist of PWM's number (1-2) and position value (0 – 255). In this case codes for relays use format: "@XY" where, X = 0, 1, 2, …7 and Y = 0, 1. For PWM: "@PWNZZZ", where N=1, 2 and ZZZ = 000, 001, 002, … 255.

All serial communication between PC and CPU used standard algorithm with parameters as: baud rate = 19200; data bits = 8; parity = none; stop bits = 1; flow control = hardware. These parameters can be set at both MCU and PC.

2.3 Software

The software includes operating system (OS), a program which was composed in Visual Basic® (VB) and html scripts in ASP, and installed in the PC. For this purpose, Windows® XP SP3 was used with IIS® (Internet Information Services) and Remote Desktop® enabled. Program in VB was used to handle data acquisition (reading, converting, displaying, and storing), switch control, and capturing pictures form webcam.

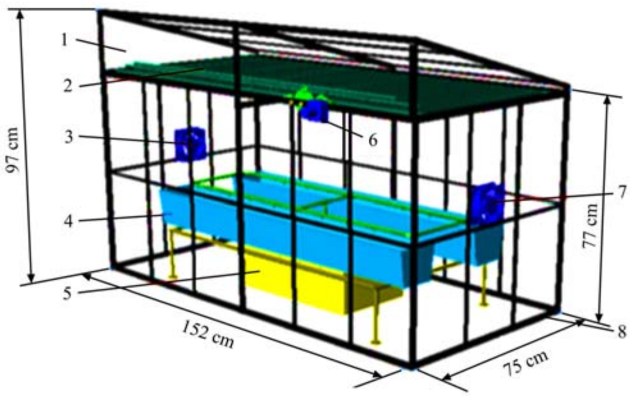
Data acquisition program receives ADC's output from MCU consecutively. The received raw data was then converted to appropriate unit using equations obtained in calibration. Both raw and processed data are displayed on screen monitor and stored in files with an interval of about 20 seconds. The files can be accessed by other program/application such as graphing software, switch control as reference of automatic mode, and html/ASP script for publishing on website.

Program of switch control provides control of each relays under three modes, including manual, timer, and automatic which can be selected independently. If "manual" is selected, two buttons ON and OFF appear. Timer mode makes switch ON and OFF alternately with intervals that can be set. The interval values will appear when timer mode is selected. Automatic mode needs set point value and actual value input from sensor as reference. If "automatic" is selected, value of set point will appear that can be changed to desired value. Program will send special code to MCU via serial port to make a switch ON or OFF.

2.4 Model greenhouse

To conduct test performance of the control system, a model greenhouse was fabricated. This laboratory scale greenhouse was equipped with actuators such as fans, sprayer, mechanical shading, lamp, and camera rotator. All actuators were electrically powered driven by ON-OFF switches except mechanical shading and rotator which were guided by PWM signal.

Figure 2 shows perspective view of the model greenhouse. Structure of model greenhouse used aluminum frames (152 × 75 × 97 cm) and plastic for cover material. Gutter pots were placed inside greenhouse and equipped with an aquarium pump, pipes, and water container for circulation of nutrient solution. Two fans were installed on left and right sides which blew ambient air into greenhouse and pushed hot air out through net-ventilation on upper front side of greenhouse. Two nozzles were placed inside and connected to a spray pump through hoses. These acted as humidifier and cooler.



1. Ventilation 2. Glass blades 3. Fan 1 4. Gutter pot 5. Water/nutrition container 6. Motor and gears as part of mechanical shading 7. Fan 2 8. Aluminum frames

Figure 2 Model greenhouse

A tube lamp was placed at the upper side to provide necessary illumination at night when needed for capturing pictures via webcam. For controlling light intensity during daytime, a mechanical shading unit was installed. It was adapted from louver blades window mechanism to cover crops area (shadow). DC motor and reduction gears were used to rotate blades in desired position/level using servo mechanism driven by PWM signals.

2.5 Performance test of the control system

The main purpose of this test was to exhibit that the control system can work smoothly as intended. This was done by testing each element individually and collectively towards overall performance of the system. The tests were planned for data acquisition unit, switch control unit, and PWM-based control.

The overall performance was tested by installing control system on the model greenhouse. Lettuce (*Lactuca sativa*) crop was selected to be cultivated using hydroponics because it has relatively short lifecycle and quick production capabilities (Mendicino, 2005). Control system was operated during entire growing period (50 days) 24 hours per day. As part of the control system, PC's CPU was placed in an instrument box together with other electronic accessories. Sensors were placed inside and outside greenhouse, and connected to the instrument box via cables. All actuators were also connected to the instrument box via cables. Instrument box was made waterproof to protect all electronic parts from moisture/dust. To prevent overheating inside the box, two exhaust fans were installed on both sides of it.

The CPU was connected to the network via UTP cable. All supported programs were placed on start-up, so that these are executed automatically when CPU starts. IIS was installed to provide web server where webpages (html and ASP script) are loaded so that these can be accessed using web browser from devices including smartphones. Windows XP provides Remote Desktop (RD), which enabled the computer to be accessed from other computer connected via network. A static IP address of the CPU was set within the network. It was an identity for accessing it remotely via RD or website. The campus network provides connection both cable and WiFi over the area including office buildings, residence building and other public areas. Remote Desktop on other computer was used to access controller system via internet connection. RD recognizes the CPU using the unique IP address, user name and password. By this method, all resources on CPU were totally accessible including webcam and greenhouse control system.

Performance of control for each actuator was evaluated by observing the related parameter change during automatic operation mode. Status of actuators (ON/OFF) at any time was recorded. Timer mode was evaluated by comparing actual time resulted in operation of switch with specified setting time.

Two actuators were controlled by PWM signal including mechanical shading and camera rotator. Actuators control performance was tested by generating PWM's parameter and measuring their corresponding angular positions. Effect of control to light intensity was evaluated in performance test of mechanical shading.

3 Results and discussion

3.1 Designed control system

Electronic devices were assembled on printed circuit boards including signal conditioning/amplifier, multiplexer, MCUs, relays, and power supply. Two MCUs (ATMega8) were used separately for input and output because of limited number of MCU's pin, and to avoid any conflict between receiving and sending data in serial communication with PC. As the PC provides several serial ports (COM and USB), addition of MCU as serial device is feasible with no significant additional cost.

First MCU consists connectors for sensors (eight units), serial com (two units), PWM signal (two units), and switches (eight units). MCU program for sending ADC output was composed using BASCOM-AVR® with a simple algorithm. Results of the program were checked by connecting the serial cable to PC via COM1. By using Hyper Terminal, data from MCU were received properly.

Second MCU was employed as interface of PC to control relays, and to generate PWM signal via serial communication. It operates by receiving codes from PC and interpreting the code to the control actions to relays or PWMs. Eight switches were available on this MCU although only five were used. As PORTB1 and PORTB2 were used as PWM output, these were replaced by free pins: PORTD2 and PORTD3 respectively. The MCU worked properly when the serial cable was connected to COM2 on PC using Hyper Terminal. By sending a code from PC, reaction of MCU was observed. Status of switch is indicated by LED provided at each relay. PWM signals were tested by connecting the outputs to servo motors. Angular position of rotor was observed as the effect of PWM parameter.

3.2 Software

Two main programs were composed. First program was used to handle measurement unit (data acquisition). Functions of the program were (i) to capture data from COM1; (ii) to separate data into eight kinds that are delimited by "/"; (iii) to store data in files; (iv) to convert data in binary value to proper unit using conversion equations obtained in calibration; and (v) to display data on screen monitor. A file named "YYMMDD.cdt" was created automatically for storing original data including time at 20 seconds interval. Nine fields per record including Time, T1, T2, RH1, RH2, Light1, Light2, MC1, and MC2 were recorded. These files were accessed by other program/application such as graphing, webpages (ASP) and Excel® for data analysis.

The other program was used to control switches and servo motors. It provides five switches in three modes of operation (manual, timer, and automatic). It displays virtual greenhouse with actuators as shapes which change their color (red or black) indicating their status ON/OFF. These actuators were SPRAYER, FAN1, FAN2, PUMP, and LAMP. Two actuators were controlled proportionally using sliding bars; these are mechanical shading and webcam rotator. One additional actuator was used to plug/unplug USB connector of webcam. ON-OFF control of actuators was done by sending corresponding code as previously described. Figure 3 shows visual interface of this program which is named as "Greenhouse Control System". Five actuators are provided, as indicated by black rectangular boxes. Each actuator is connected with a frame that consists of name, mode options, etc. In manual mode, two buttons "On" and "Off" will appear.

3.3 Remote access

The system was designed to be controlled remotely. It used intranet which was accessed using RD and website. Monitoring and control of the greenhouse was done using designed programs (Data Acquisition and Greenhouse Control System). Visual monitoring was provided using webcam and its application software under Windows XP which was capable to capture pictures and store it in files.

Web pages are also provided in the system so that it could be accessed using browsers such as Internet Explorer®, Google Chrome®, Opera®, and mobile browsers (Android®, Opera Mini®, etc.). For monitoring purpose, climate data and status of actuators were provided on website as free accessed. But secure website has been used to protect the control system from unauthorized access. Figure 4 shows webpages accessed using Android smartphone.

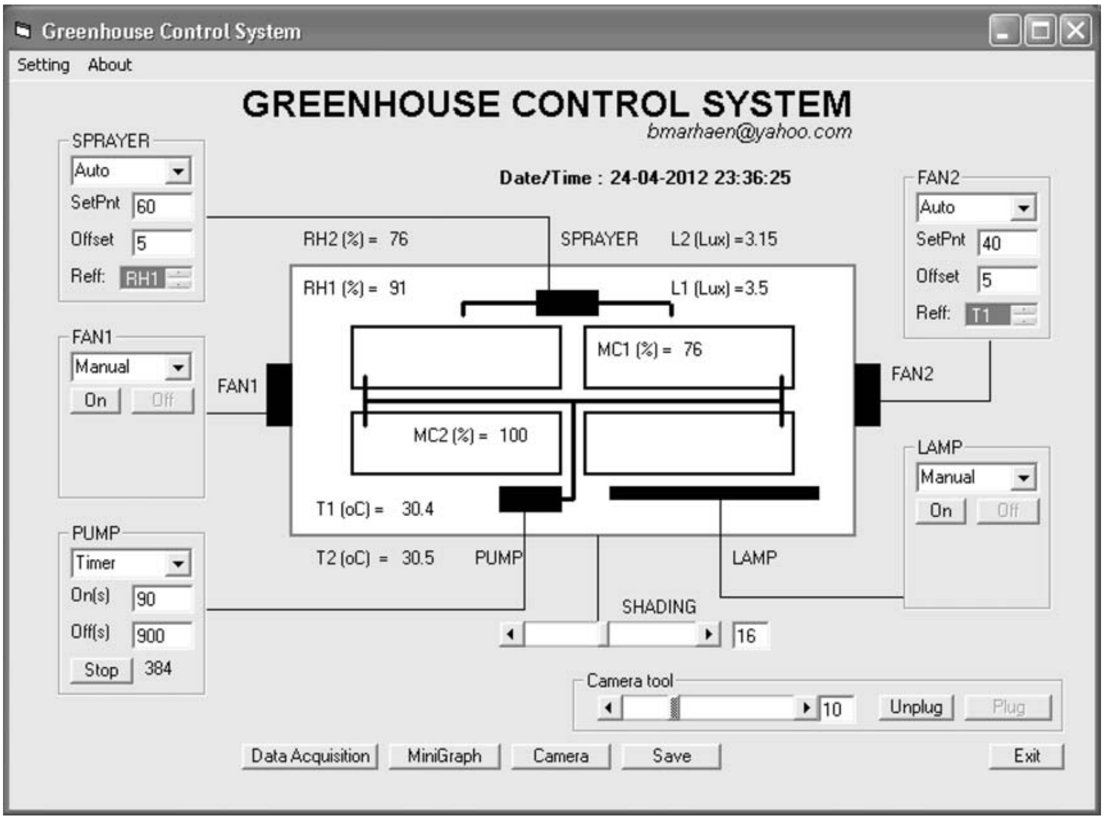
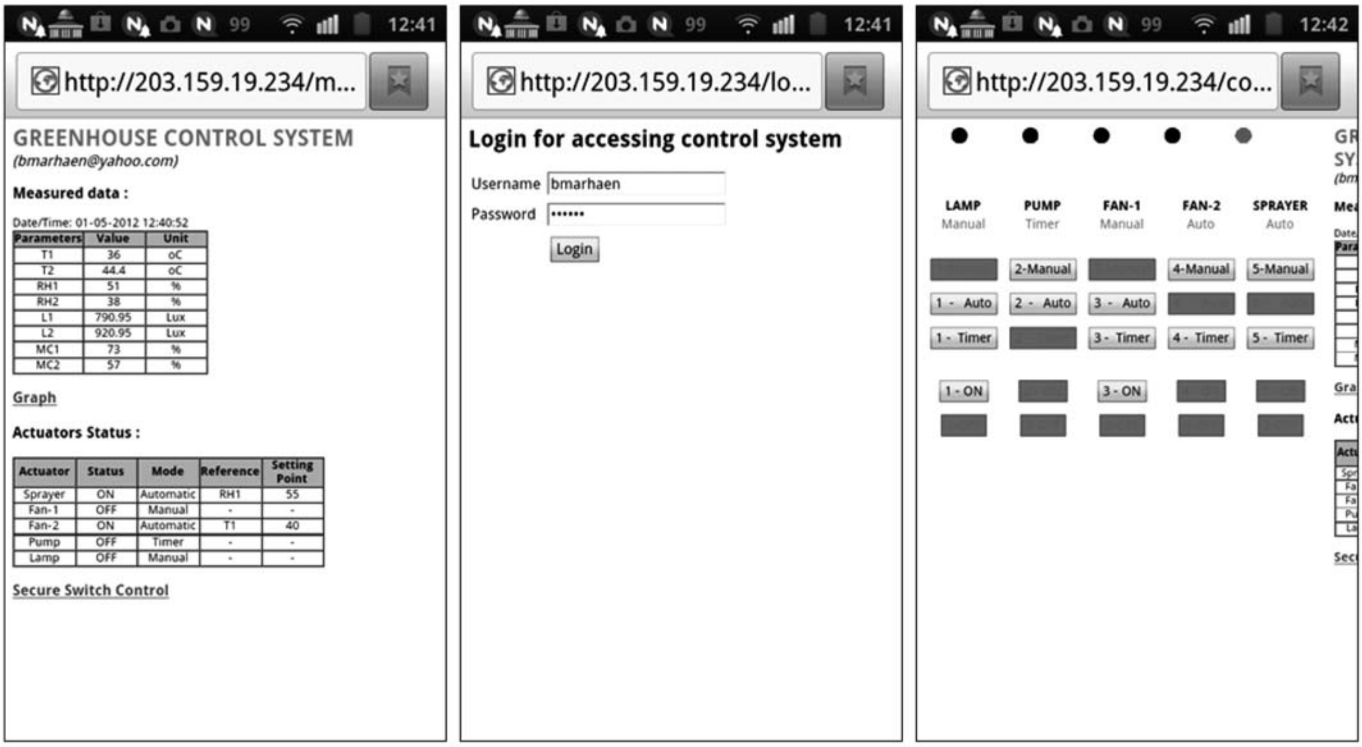


Figure 3 Greenhouse Control System



a. Homepage shows current data and status of actuators b. Login page for accessing control system c. Secure page for controlling greenhouse

Figure 4 Simple websites for accessing greenhouse control system via smartphone

Accessing control system by VB program and ASP script (web) needs to synchronize between two different platforms. For this purpose, a text file is used in which codes of control are stored. It is an ASCII file which can be accessed and edited by several software and programs. A procedure, as part of the program reads codes from the file and converts it to control action by sending switch codes to MCU. Control program and

ASP script (web) will manipulate text in the file. Figure 5 shows how the file is accessed by three applications.

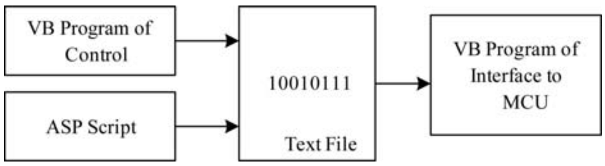


Figure 5 Accessing text file by multiprogramming

3.4 Control performance

Performance of the system was tested by installing all components on the model greenhouse. Data collection started in March 2012 at open field within AIT campus, Pathumtani, Thailand. Data were recorded during the test by data-acquisition software for temperature, humidity, light, and moisture content. Operating status of actuators (pump, fans, sprayer, and lamp) as well as photographs of lettuce growth were recorded.

Temperature and humidity changes were recorded during test at various control modes. Variation of the microclimate without any control is shown in Figure 6. Symbol with index 1 indicates location of sensors is inside greenhouse; index 2 refers to outside. Inside temperature (T1) is higher than outside (T2) with deviation affected by solar radiation intensity. Humidity (RH) has opposite trend to temperature; RH inside is lower than outside. Differences of light intensity between inside (L1) and outside (L2) indicates existence of barrier to air exchange from plastic cover and shading unit. Spikes of L1 at night (2 a.m., 8 p.m., and 10 p.m.) indicates turning ON the lamp manually for any reason; it shows that the lamp could provide about 8000 Lux at night.

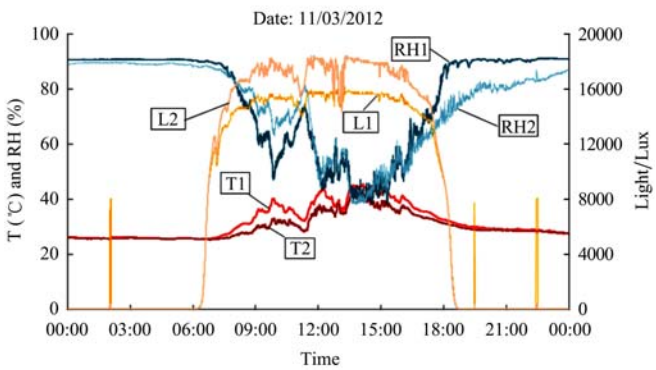


Figure 6 Observed microclimatic data during test without control

This observation was taken before planting lettuce. It shows that maximum temperature inside greenhouse was about 45℃ while outside was about 40℃ at about 2 p.m. At the same time, inside and outside RH were at minimum (about 40%). At night, RH outside was lower than inside. Both RH started to decrease at 7 a.m. and started to increase at about 3 p.m.

On the next day, a treatment of control was done by operating sprayer pump manually. At about 1 p.m. sprayer was switched ON for about 10 minutes followed by the next switching ON for a minute, after one hour OFF. Again at 3 p.m. it was switched ON for a minute. Effect of this treatment is shown in Figure 7. It indicates that the operation of sprayer increased RH and decreased T as desired. Operation of sprayer made RH1 increased rapidly from 40% to 90%, so did T1 from 45℃ to 30℃. It also affected RH2 and T2 due to location of outside sensors were in the front of ventilation. After sprayer switched off, RH had gradually decreased and T increased. The graphs show loss of data at 7 p.m. onwards due to incidentally power cut off.

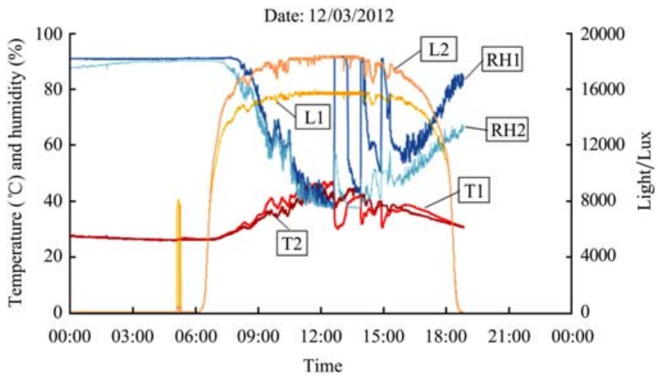


Figure 7 Effect of manual control of sprayer on RH and T

Automatic control of sprayer and fan was then opted at set points 55% RH (offset = 10%) and T = 40℃ (offset = 5℃). Dynamic response of this control to RH1 and T1 is shown in Figure 8. Sprayer turns ON when RH falls to 55% which causes it to rise up until 65% (offset = 10%) and sprayer automatically turns OFF. Again naturally RH decreases due to moisture adsorbed by plant and mixed by outside low RH air (ventilation effect). Fan turns ON if T increases to 40℃ which makes it decrease until 35℃ (offset = 5℃) it turns OFF and T starts to increase as the effect of solar radiation.

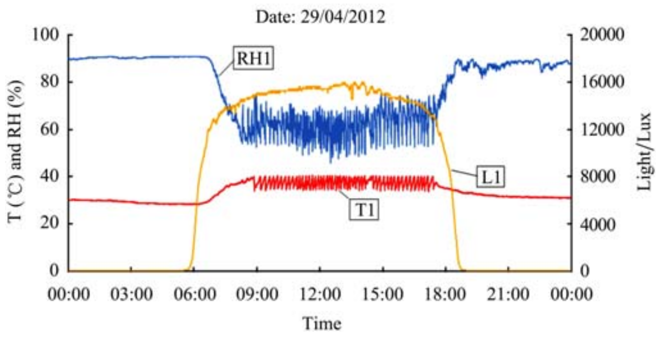


Figure 8 Effect of automatic control of sprayer and fan on RH and T

Normally, RH fluctuated in between 55%-65%, but depending on the sensitivity of sensor, and distance between nozzles and sensor, it showed response delays and slight overshoots. When RH reached set point, the control made sprayer turn ON, but RH keeps decreasing because of the propagation of moisture. Temperature fluctuation was relatively stable within the limits which indicate good response time of the sensor and actuator (fan).

Control of light was done by mechanical shading which was operated in manual and timer modes. Manual control is provided in controller program (Figure 3) as the slider bar (horizontal scroll bar). It has been calibrated so that the range of slider corresponds to the range of blade position. Maximum reduction of light intensity was achieved at minimum α (0°) as is shown in Figures 6 and 7. It shows that reduction occurs at daytime and solar luminance (L2) > 12,000 Lux (at 7 a.m. – 6 p.m.). At the time, absolute reduction varies between 34-2,650 Lux with an average of 1,808 Lux. Effect of control on light intensity was observed from shadow formed at blades angular position. Figure 9 shows shadow of blades on the pot at three different angular positions.

Lettuce plant was cultivated using hydroponics with gravels as media. Water and nutrients were circulated using a water pump controlled at the timer-mode. Figure 10 indicates changes of water availability during controlling at timer-mode (90 s ON, 900 s OFF). It shows the effect of watering on raising moisture content (MC) for 1.5 minutes, then MC decrease gradually after pump turn off for 15 minutes. It was repeated which is shown as saw graphs (10 cycles in three hours).

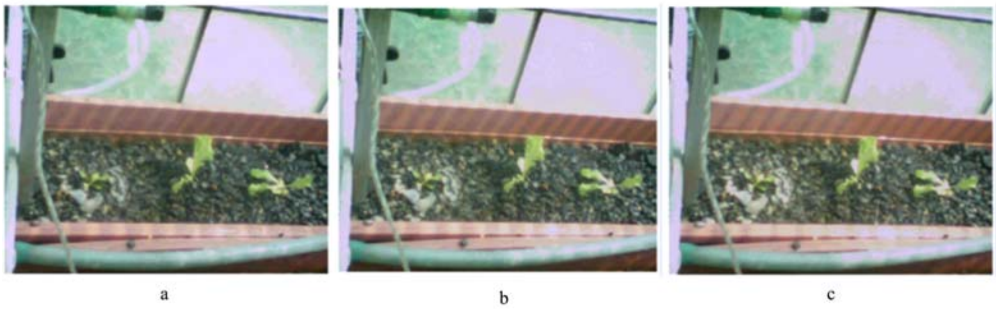


Figure 9 Forming shadow on plant pot influenced by angular position of blades
(a), (b), and (c) indicate changes of shadow density

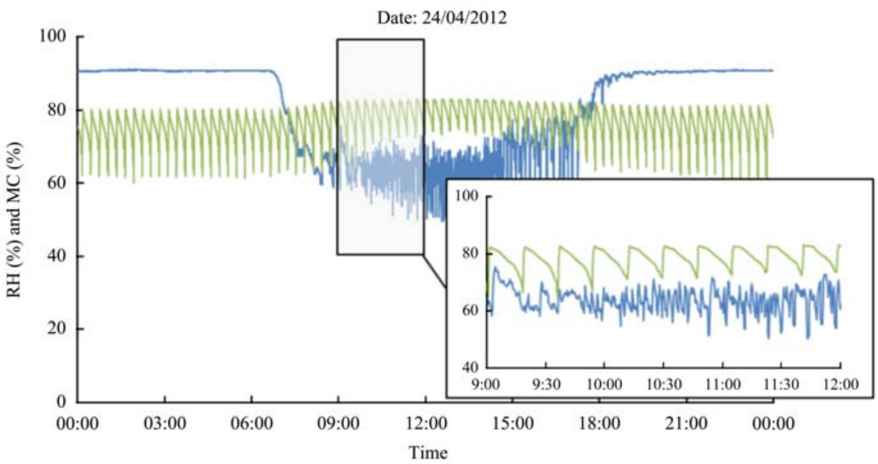


Figure 10 Variation in timer-mode of control for moisture content (MC1) and humidity (RH1) in automatic mode of control

At daytime when sprayer pump was automatically switched ON and OFF, the maximum MC slightly raised but minimum MC increased significantly. It indicates that sprayer operation affected the MC of the media.

Lettuce growth was monitored regularly during experiment (50 days) from a remote location using intranet. A webcam with rotator was installed inside the greenhouse. The angular position of rotator was determined using PWM signal generated by controller system. Various viewpoints of webcam are shown in Figure 11. At minimum value (0), angular position of rotator resulted in the leftmost viewpoint. By changing slider position to the right, the value increased and rotator moved to the right. The maximum value was 35 which made viewpoint on rightmost position.

Pictures from webcam were captured from the same viewpoint periodically and stored in jpeg files. It was done from remote terminal using RD and manually operated. During the experiment, more than 200 pictures were captured. Figure 12 shows selected pictures which describe lettuce growth. At 10th day, plants had three leaves which continuously grew with bigger four leaves at 15 DAP. After 35 days, lettuce matured to be harvested. As the pictures were observed remotely, it provided a close monitoring of plant growth as intended.

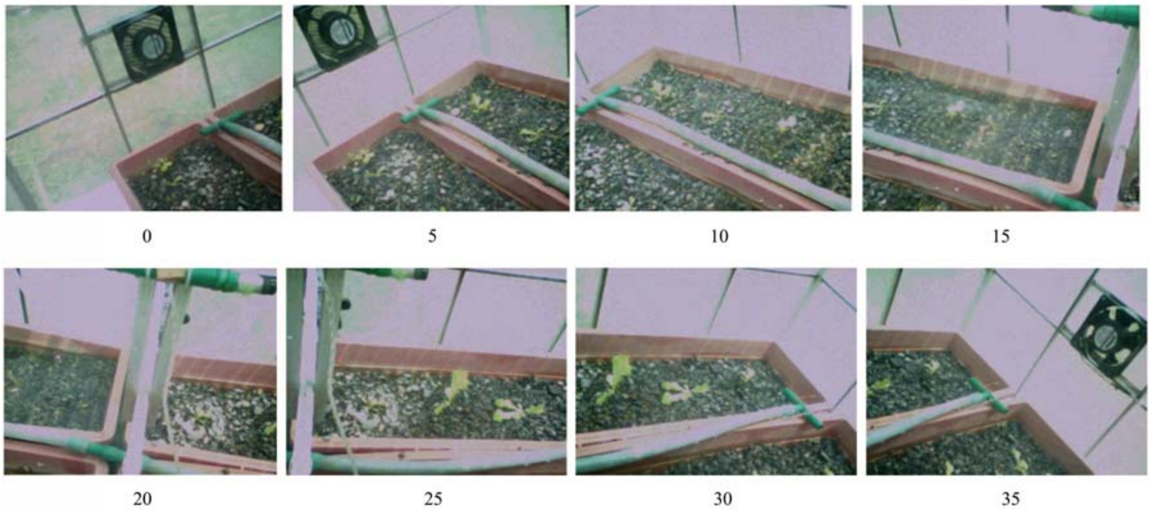


Figure 11 Viewpoints of webcam as controlled by PWM's values which are created by slider bar in controller program (Camera tools in Figure 3)

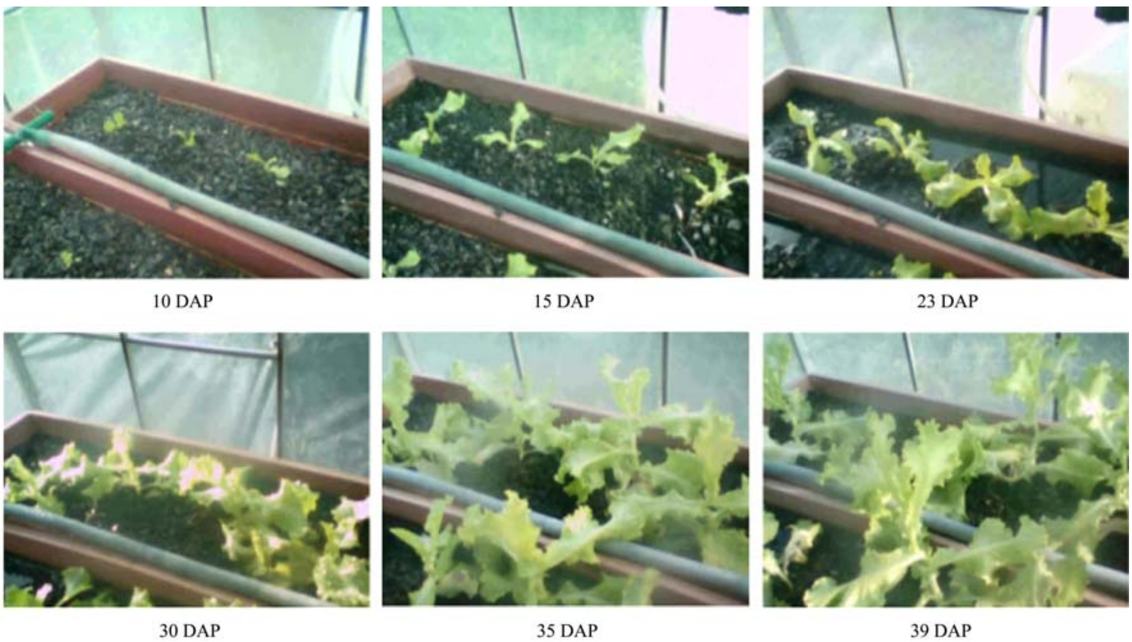


Figure 12 Lettuce growth in days after planting (DAP)

4 Conclusions

1) The study on designing a smart greenhouse control system over internet was conducted. Both hardware and software necessary to constitute the system were developed.

2) Performance of the system was tested and evaluated, which indicated that controlling four important microclimate parameters, including temperature, humidity, light, and moisture content can be done remotely over internet using Remote Desktop®.

3) Surveillance unit provided pictures of plant during growing period for remote monitoring.

4) The application of greenhouse control system over internet reaffirms its potential for part-time farmers especially under the concept of urban agriculture.

5) High value crops can be closely monitored by the owners/experts.

Acknowledgements

The authors wish to acknowledge the grant received from the Director General of Higher Education (DIKTI), Ministry of Education and Culture, Republic of Indonesia and the Asian Institute of Technology.

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