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Application of IoT technology on control system and monitoring for Cucumis Melo L. grown in greenhouse

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ABSTRACT

In this paper, we propose developing a system for optimally watering Cucumis Melo L. crops based on an application Internet of Things (IoT). The three components are hardware, a web application, and a mobile application. The first component was designed and implemented in control box hardware connected to collect crop datas. Soil moisture sensors are used to monitor the greenhouse, connected to the control box. The second component is a web-based application that was designed and implemented to manipulate the crop data and field information. This component applied data mining to analyze the data for predicting suitable temperature, humidity, and soil moisture for optimal future management of crop growth. The final component is mainly used to control crop watering through a mobile application on a smartphone. This allows either automatic or manual control of the user. The automatic control uses data from soil moisture sensors for water. The results showed the implementation to be useful in agriculture. The moisture content of the soil was maintained appropriately for Cucumis Melo L. growth, reducing costs and increasing agricultural productivity. Moreover, this work represents improvements to agriculture through digital innovation.

1. INTRODUCTION

It can be said that the development of advanced agricultural technology can bring benefits to most people today. In recent years, the IoT has played an important role in our daily lives, expanding our awareness and ability to change the conflicting environment around us. Particularly within the agricultural and industrial sectors, the IoT application environment fields in both doubt and control. In addition, it can provide information to the end user/consumer about the origin and characteristics of the test product. Therefore, this paper aims to apply IoT to optimize the assistance of computers in agriculture production (Dhanaraju, et al., 2022). It can be used to monitor and control the factors affecting crop growth and yield. They can also be used to determine the optimal time to harvest, which farmers can handle according to different conditions, detect diseases, control machines, and more (Dipto et al., 2020).

In this study, we focused on data including substrate temperature and humidity in a greenhouse enviroment. To develop a suitable system, we require data storage and an approach to discover knowledge from accumulated data and user interaction. A database system will be designed and deployed as a web-based application (Thakur et al., 2020). Stored data will make decisions to control the automatic watering of crops. Agricultural data will be analysed to optimize and change the surrounding environment, and to predict future crop water needs. As one of the important contributions, this work applied data mining to extract the best value from precise measurements with automatic microcomputer monitoring of crops, soil, and climate (Ali & Abdullah, 2022; Prieto et al., 2021; Mutyalamma et al., 2020).

Advantages of growing plants using IoT drip irrigation (Patil et al., 2021).

– Can actively adjust nutrients for plants. Nutrients are provided according to the amount of water for irrigation

– Save water because plants use drip irrigation technology, there is no loss because of infiltration or evaporation

– Reduce labour costs by not having to manually do some steps such as tilling, weeding, cultivating and watering.

– The model uses a linear interpolation algorithm to reduce the number of temperature and humidity sensor chips at the input, reducing the system implementation cost.

– Besides monitoring and remote control of the system, the project can also download and upload remote programs to change the cyclical operation of the system.

– Hardware combination of PLC controller S7-1200 and V-BOX IoT device makes the system stable, and remote control and monitoring is easy.

Understanding this, the research team made a proposal to apply IoT technology to the model of growing cantaloupe in a greenhouse to turn the cantaloupe farming model into a high-tech agricultural model using temperature sensors., humidity, light, pH, EC to well control nutrient concentration and connect to 3G and Wi-Fi networks to monitor from anywhere, anytime, creating the most ideal growing conditions for cantaloupe. Farmers will not need to be present 24/7 at their farm and still be able to control input parameters such as nutrient concentration, pH, temperature, humidity to optimize yield and minimize risk, towards in a precision agriculture.

2. MATERIALS AND METHOD

2.1. System model

The research team made a proposal to apply technology to the model, to turn the model of growing cantaloupe in a greenhouse into a high-tech agricultural model using sensors for temperature, humidity, light, and pH., to well control the nutrient concentration for cantaloupe plants and connect to 3G and Wi-Fi networks to monitor from anywhere, anytime, creating the most ideal growing conditions for cantaloupe. Farmers will not need to be present 24/7 at their farm and still be able to control input parameters such as nutrient concentration, pH, temperature, humidity to optimize yield and minimize risk, towards in a precision agriculture (Muangprathub et al., 2019).

While various greenhouses growing melons across the country have sprouted up, there is still a lack of a solution that can help farmers automate their greenhouses, control, and optimize productivity instead of relying on experience and expertise judgement. The research team has researched and come up with a solution to apply its technology to the model of growing cantaloupe in a greenhouse. The advantage of the system is that it uses sensors and cloud computing technology to monitor most of the inputs affecting the crop yield, such as growth control, disease identification on leaves, concentration of water-soluble nutrients (EC), pH, multi, medium and trace elements, temperature, humidity, control of pumping system, misting, sun cutting. All controlled 24/7 via smartphone and PC apps (Priya & Sudha, 2021).

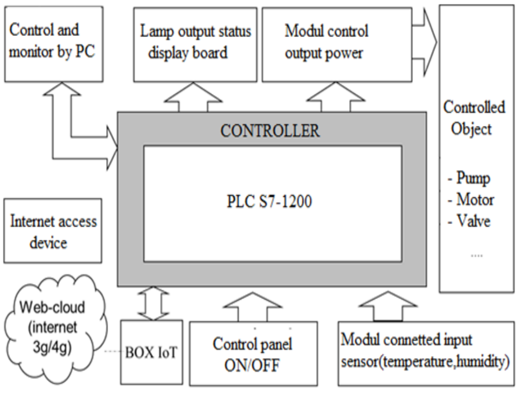


Figure 1. Control system block diagram

Always controlling the input factors can minimize risks and bring benefits such as:

– Farming model, saving area but higher yield from 25 to 500%

– Save up to 95% water usage compared to conventional models

– Applying sensor technology to measure nutrient concentrations, minimizing nitrogen residues (N03)

– Using greenhouse and insect screen systems to reduce the spraying and pesticide use by 100%.

– In line with the policy of the Party and the State of Viet Nam on the application of high technology to agriculture in drought conditions and contaminated soil (Wecon V-NET Web, 2023).

Page 1: Control and monitor the system in manual mode (irrigation, rain spray, sunshade, open sunshade). Load status, temperature and humidity values are displayed visually through animations and decimal numbers.

2.2. Design interface

Steps to implement interface design on web cloud (WECON VIETNAM, 2020)

Step1: Open the application software V-NET Access (User manual V-BOX, 2023)

Figure 2. V-NET Access application interface - log in to your account

Step2: Log in to your user account.

Step3: Select the Cloud SCADA

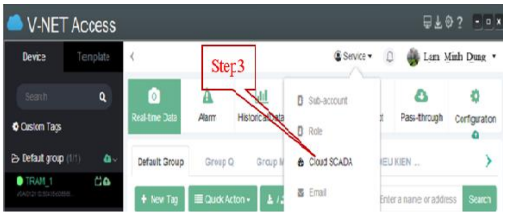
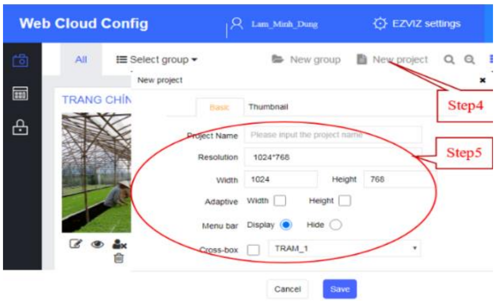


Figure 3. Cloud SCADA page design card opening interface

Step4: Open the design project for the control system.



New project
Project Name: Please input the project name
Resolution: 1024*768
Width: 1024 Height: 768
Adaptive: Width ☐ Height ☐
Menu bar: Display ● Hide ○
Cross-box ☐ TRAM_1

Figure 4. Interface for naming and setting resolution for web cloud

Step5: To name and choose resolution for the cloud website.

Figure 5. New Cloud web design window page

Step6: Select objects

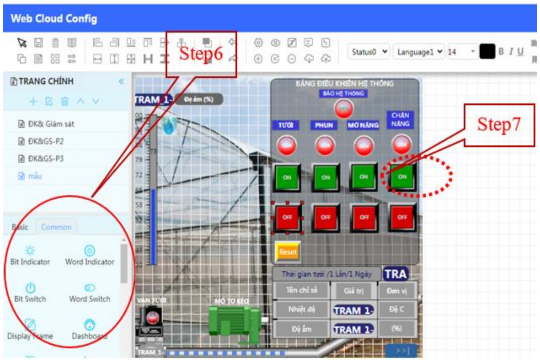


Figure 6. The interface takes objects present in the actual system

Step7: Link objects to tags in PLC S7-1200

Figure 7. Interface that associates web cloud objects with tags in PLC

Step8: Repeat step 7 for remaining objects

Step9: Run web cloud and check web cloud against technical requirements for the system.

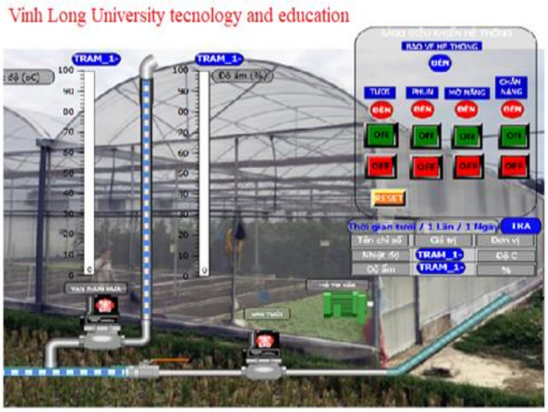
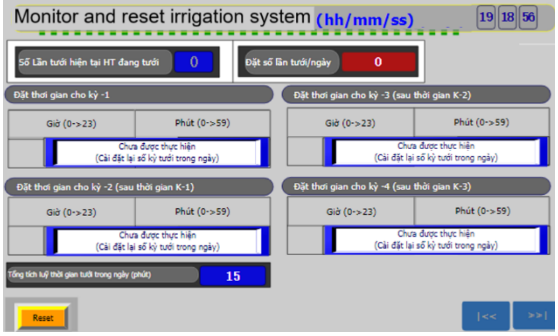


Figure 8. Control panel interface and cloud monitoring

Page 2: Monitor and allow to reset parameters in automatic mode in real time: hours/minutes/seconds of the day.



Số Lần tưới hiện tại HT đang tưới: 0

Đặt số lần tưới/ngày: 0

Đặt thời gian cho kỳ -1: Chưa được thực hiện (Cài đặt lại số kỳ tưới trong ngày)

Đặt thời gian cho kỳ -2 (sau thời gian K-1): Chưa được thực hiện (Cài đặt lại số kỳ tưới trong ngày)

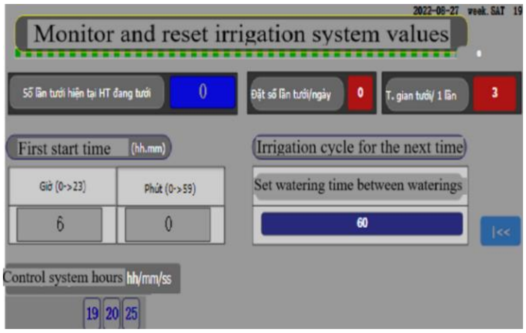
Đặt thời gian cho kỳ -3 (sau thời gian K-2): Chưa được thực hiện (Cài đặt lại số kỳ tưới trong ngày)

Đặt thời gian cho kỳ -4 (sau thời gian K-3): Chưa được thực hiện (Cài đặt lại số kỳ tưới trong ngày)

Tổng tích luỹ thời gian tưới trong ngày (phút): 15

Figure 9. Monitoring and resetting for irrigation systems (according to h/m/s)

Page 3: Monitor and allow to reset parameters in automatic mode in real time: hours/minutes/seconds of the day and the number of watering times change according to the cycle of the day.



Số lần tưới hiện tại HT đang tưới: 0

Đặt số lần tưới/ngày: 0

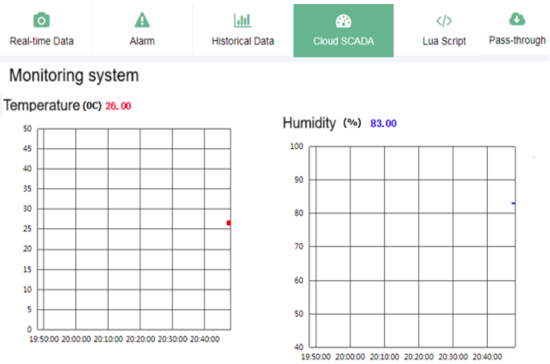
T. gian tưới/ 1 lần: 3

First start time (hh.mm): Giờ (0->23) 6, Phút (0->59) 0

Set watering time between waterings: 60

Figure 10. Monitoring and resetting irrigation systems. (According to preset cycle)

Page 4 Interface to collect real-time temperature and humidity data



Temperature (oC) 26.00

Humidity (%) 83.00

Figure 11. Monitor temperature and humidity on graphs in real time (Cloud SCADA)

All data is aggregated to the central processor using PLC1200 and sent to the cloud of V Box. The data will then be automatically synced to the app on your smartphone and PC.

3. RESULTS AND DISCUSSION

3.1. Experimental Environment

Collect and analyze input signals:

Table 1. Input ON/OFF signals for the system

Input agent name	Symbol	Note
Push button	PB-1	NO, Running and stopping the drip irrigation system
Push button	PB-2	NO, control running and stopping the sprinkler system
Push button	PB-3	NO, control running and stopping the system to open the sunshade (light up)
Push button	PB-4	NO, control running and stopping sunshade framing system (light blocking)
Push button	Reset	NO
Open limit sensor	Sensor_O	NO, detect sunshade frame working at full open stroke
Close limit sensor	Sensor_C	NO, detect sunshade frame working at the end of the closing stroke

Table 2. Analog input signal from temperature and humidity sensor

Agent name input	Symbol	Note
Heat sensor	Sensor_tem	0 to 10 volt
Humidity sensor	Sensor_hum	0 to 10 volt

Table 3. Data from programming device, system, and web cloud data transmission

Input agent name	Memory area	Note
Intermediate control variables	Mxx.x	1 bit
Variables allow reading and writing of temperature and humidity values from the sensor	DBW	16 bit
Variables allow reading and writing of counters, time.	DBW	16 bit
Variables that allow reading and writing of reference values in real time	DBB	8 bit

Collect and analyze performance requirements in the system.

(I) The system operates through a request from the operator:

(1) At the request of the system administrator: It is allowed to edit, reconfigure the system, assign permissions to users, write/read values in the system and monitor.

(2) At the request of a technician to monitor and control the system: Only write/read values in the system and monitor.

(3) System monitors: Only the system can be monitored.

(II) The system operates under physical conditions

(1) According to temperature conditions: Follow the standard temperature conditions allowed in the system.

The ambient temperature of the greenhouse is <36° C, and requires opening the sun-shade.

The greenhouse environment temperature >= 36°C, requires sun shading combined with periodic control of rain film to reduce heat in the greenhouse.

(2) According to humidity conditions: Follow the standard humidity conditions allowed in the system

The humidity of the greenhouse environment is < 50%, sprayed to increase humidity.

(III) Collect and analyze requirements according to greenhouse control system response.

(1) Irrigation valve controls the average amount of water for crops in each period.

(2) Open frame traction motor/shade and cooling sprinkler valve can be controlled according to the ambient temperature in the greenhouse and real time.

Table 4. Irrigation mode, providing nutrition for melons

Period	Number of watering times (times/day)	Irrigation time (minutes/time)	Amount of water (liters/potting/day)
Planting (14 days)	10	2	1,5
15 days after planing(lowering)	10	3	2,0
Fruiting	20	2	2,6

Table 5. Conditions for turning on/off the sprinkler valve and open/blocking glue motor

Real-time	Temperature inside the greenhouse	Rainy weather outside the greenhouse	Rainy weather outside the greenhouse	Rain spray valve
Time: 9h – 16h	< 36°C	x	open	OFF value
	>36°C	No rain	Sunshade	Open valve periodically 20m: open 3m- off 17m.
		rainy	Shade	OFF value
Time: < 9h and >16h	x	x	Open the light	OFF value

3.2. Experimental results

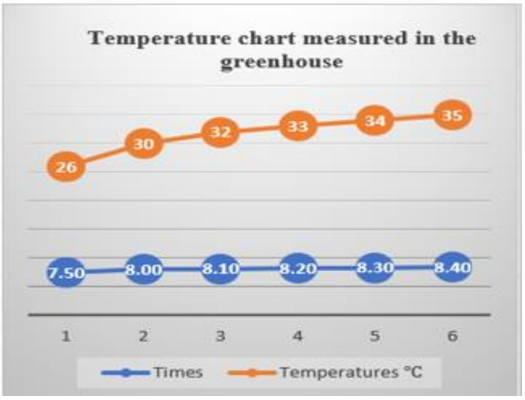


Figure 12. Temperature chart measured in the Greenhouse

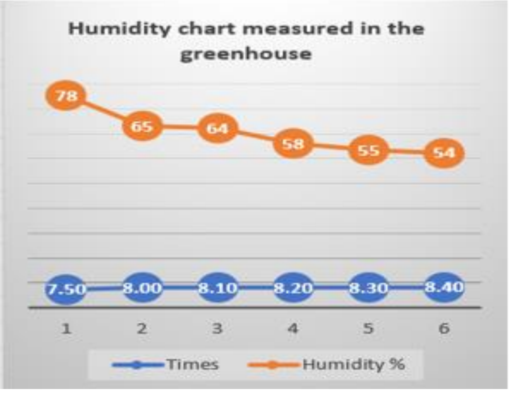
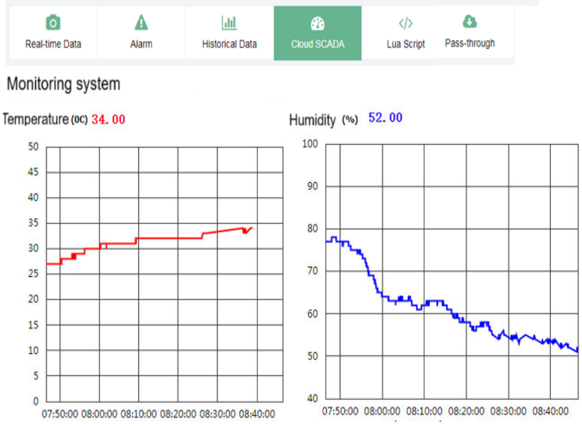


Figure 13. Humidity chart measured in the greenhouse



Monitoring system

Temperature (0C) 34. 00

Humidity (%) 52. 00

Figure 14. Temperature and humidity collection chart

The system for monitoring and collecting environmental temperature and humidity data in the greenhouse is the same as the manual measurement results.

Figure 16. Deploying the system of growing Cucumis Melon L. in the greenhouses

Figure 15. Greenhouse system control cabinet

4. CONCLUSIONS

We have researched the application of IoT technology and drip irrigation technology to turn the cantaloupe farming model into a high-tech agricultural model using temperature, humidity, light sensors well control tree growth and using 3G, Wi-Fi to monitor from anywhere, anytime, creating the most ideal growing conditions for cantaloupe. We understand very well the benefits of the model, the payback, the market price of the cantaloupe, creating an opportunity for farmers to increase profits.

Besides remote control and monitoring for Cucumis Melo L. grown in the greenhouse, it is also be effectively applied in other fields such as fisheries, animal husbandry, and environmental protection.

It is necessary to upgrade and integrate sprinkler irrigation systems inside the greenhouse; the exhaust fan system; lighting systems; irrigation system combined with fertilizing, watering drugs automatically when conditions permit. Using a wireless sensor chip when the area of the greenhouse increases, install a real camera to observe the growth and development of plants, providing reasonable control solutions for sprinkler irrigation, drip irrigation or light blocking.

However, the system model still has some limitations that need to be addressed in the future. The temperature and humidity sensor used in the project is a wired sensor, so when the number of sensors increases, the system becomes cumbersome. The design, installation, and operation of the blocking system are not flexible between automatic and normal modes. The camera has not been used in monitoring the crop system but monitoring the operating system on a phone or a computer with an internet connection through specialized software to see the visual images.

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