Sensors and Materials, Vol. 35, No. 7 (2023) 2449–2456
MYU Tokyo

S & M 3334

Web-based Crop System

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(Received April 7, 2023; accepted June 26, 2023)

Keywords: crop system, online monitoring, remote parameter control, IoT

Traditional farming is often affected by unpredictable environmental hazards, such as cold or hot weather, typhoons, flood, and drought, and requires considerable labor. To overcome such difficulties, we developed a web-based crop system to monitor and control environmental parameters such as air temperature, air humidity, sunlight intensity, and soil moisture. The system also operates sunlight-blocking curtains, ventilation/cooling fans, water sprayers, and an alarm on the basis of preset values of the parameters or manually online. The monitored parameters are shown on a mobile device through a low-cost open-source IoT platform (NodeMcu). The programs for operations are created in C# and JavaScript. The proposed system helps users grow crops in greenhouses efficiently by controlling the environmental parameters and necessary facilities remotely.

1. Introduction

Multiple cropping or multicropping is a strategy of land management for increasing agricultural production and diversifying crops in tropical and subtropical climates.(1) As stated by Bertrand *et al*., intensive agriculture, which has been criticized for its negative impacts on the environment and human health, can be improved by allowing living organisms such as earthworms to inhabit crop fields.(2) To lessen the effect of climate changes and increases in population and crop production, crop management technologies have been adopted in the Mediterranean region by enhancing land productivity and sustaining soil fertility.(3) As analyzed by Sinclair and Vadez, grain legumes can play an essential role in increasing the levels of nitrogen and phosphorus in cropping systems.(4)

The enhancement of soil fertility and symbiosis with earthworms are important in suppressing the environmental impact induced by the greenhouse effect and in increasing crop productivity.(5) Buchholtz and co-workers(6,7) designed a greenhouse to maintain constant temperature and humidity. Montero *et al*.(8) and López *et al*.(9) found that a plastic-made greenhouse is appropriate for protecting crops. To reduce the workforce, the Internet of Things (IoT) has been applied to the management of greenhouses.(10) Chiu, in 2010, presented an automatic thermal control of greenhouses using a remote-controlling system on the Internet.(11)

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https://doi.org/10.18494/SAM4453

ISSN 0914-4935

To increase crop productivity, in this study, a web-based crop system equipped with multiple environmental sensors and actuators is presented for greenhouse farming. The system is designed to monitor and control environmental parameters such as air temperature, air humidity, sunlight intensity, and soil moisture. The parameter values are shown on the user's mobile devices or personal computer (PC). The system transmits the pictures captured by cameras operating on internet protocol (IP camera) to the user via a cloud server and Wi-Fi, and activates alarms in the case of intrusion.

2. Crop System

The proposed web-based crop system has sensors to monitor air temperature, air humidity, sunlight intensity, and soil moisture and five actuators to operate the sunlight-blocking curtain, ventilation/cooling fan, water sprayer, and alarm. An IP camera is included in the system. (Fig. 1 and Table 1).

The ventilation fan and the sunlight-blocking curtain are maneuvered by the motor in accordance with the temperature inside the greenhouse to maintain appropriate temperature and light intensity ranges. The water sprayer controls the air humidity on the basis of the soil moisture sensor output. The security alarm is activated when an intrusion is detected by the switch on the door. The control logic of the system is illustrated in Fig. 2.

As access to the wired network is limited in most remote rural areas, the proposed system is based on IoT cloud technology to connect to mobile access points and monitor the growth of crops in the greenhouse. In the system, a microcontroller embedded in the Wi-Fi module using a low-cost open-source IoT platform (NodeMcu) is adopted. The operating program for NodeMcu is depicted in Fig. 3. The wiring diagram for the crop monitoring and controlling system, and the interface of the mobile device is shown in Figs. 4 and 5.

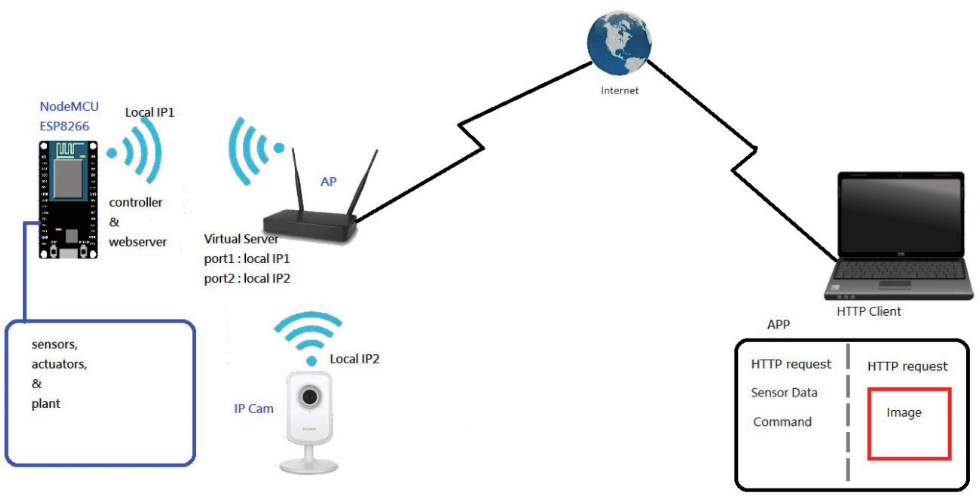

Fig. 1. (Color online) Proposed web-based crop system.

Table 1
Sensors used in the proposed web-based crop system.

Sensor	Specification	Model/Manufacturer
Air temperature	Temperature measurement: 0−50 °C Accuracy: 0.1 °C	DHT11 / DFROBOT
Air humidity	Accuracy: ±4% in relative humidity (Maximum ±5%) Operating temperature: ±2.0 °C Resolution or sensitivity: 1% RH Repeatability: ±1% RH; Long-term stability: ±0.5% RH/year Sensing period: 2 s on average Dimensions: 12 × 15.5 × 5.5 mm Digital signal via single-bus polymer resistor	DHT11 / DFROBOT
Soil moisture	Voltage: 3−5 V Range: 0−45% volumetric water content Operating temperature: −40–60 °C Dimensions: 89 × 18 × 7 mm (active sensor length of 50 mm)	SEN13322 / SparkFun
Sunlight intensity	Voltage: 3−5 V Light range: 0−65535 lx Operating temperature: −40−85 °C Serial data signal current: 7 mA Power dissipation: 260 mW	GY-30, BH1750FVI / JMaker Workshop

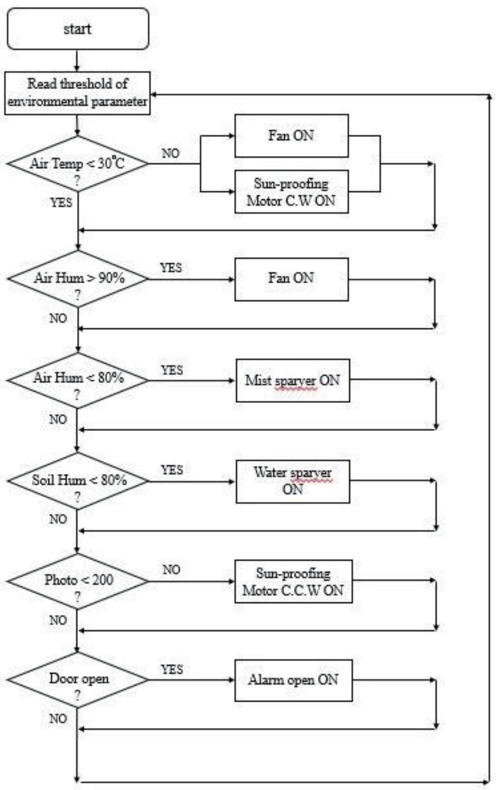

Fig. 2. Flow chart of the proposed system's control logic.

```
DHT dht(dhtPin, dhtType); // Initialize DHT sensor
#define temt6000Pin A0
#define Soilmoisture 15

int fun = 5;
int spray = 4;
int REV = 14;
int FWD = 12;
int Watering = 13 ;


#include <ESP8266WiFi.h>

const char* ssid = "ccut1234";
const char* password = "60001714";



bool FWDvalue = HIGH;
bool FUNvalue = HIGH;
bool SPRAYvalue = HIGH;
bool REVvalue = HIGH;
bool Wateringvalue = HIGH;
int op_mode = 0;
WiFiServer server(80);

void setup() {
  Serial.begin(9600);
  delay(10);
  pinMode(fun, OUTPUT);
  digitalWrite(fun, LOW);
```

Fig. 3. (Color online) Operating program of NodeMcu.

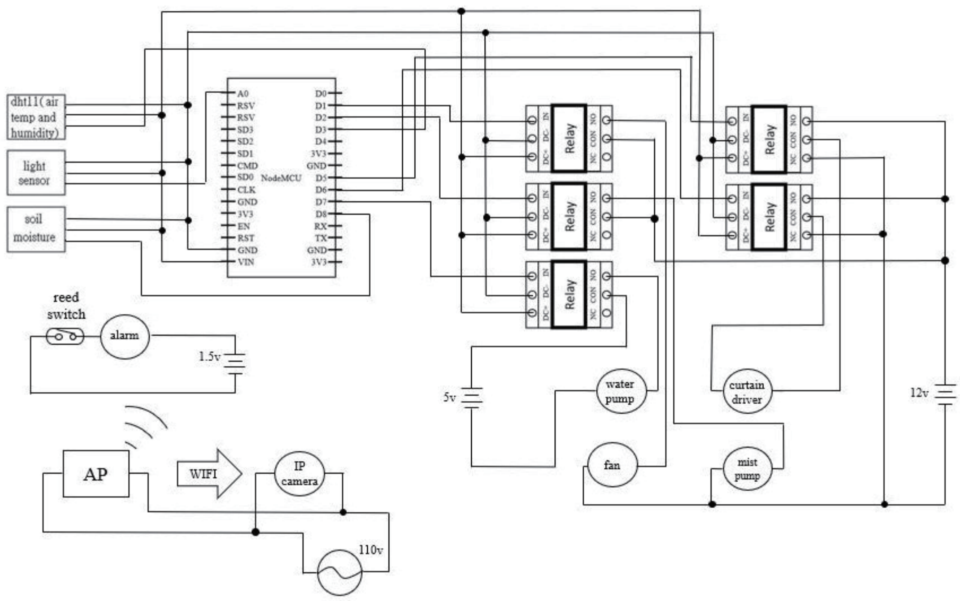

Fig. 4. Diagram of wiring for the proposed crop monitoring and controlling system.

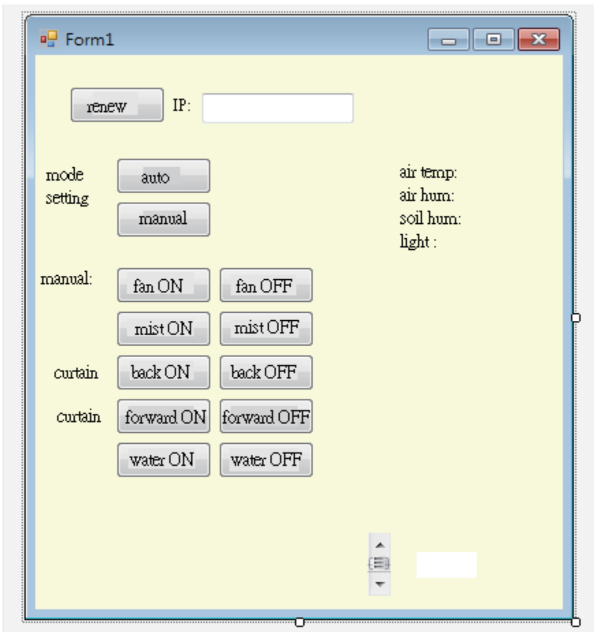

Fig. 5. (Color online) User interface of the proposed crop monitoring and controlling system.

The microcontroller programmed by JavaScript plays the role of a web server in the proposed system. Users can log in to the web server by using the user interface programmed by C#, as shown in Fig. 6. As illustrated in Fig. 5, environmental parameters, including sunlight intensity, air temperature, air humidity, and soil moisture, are shown on the interface. Two modes (auto and manual modes) can be selected on the user interface of the mobile device. The environmental

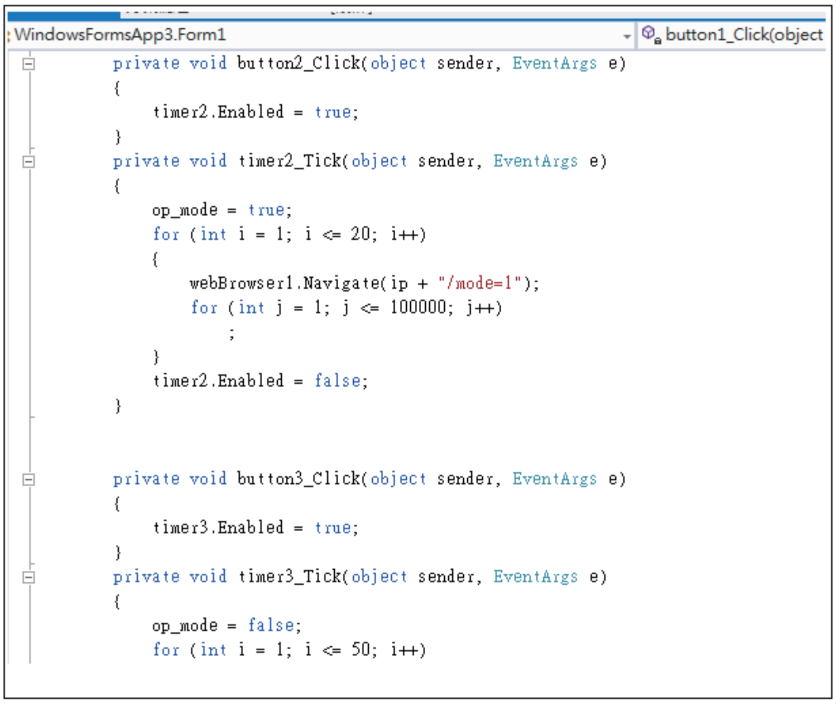

Fig. 6. (Color online) C# program for operating the proposed crop monitoring and controlling system.

parameters are automatically controlled when the auto mode is selected. The operation of the ventilation fan, water sprayer, sunlight-blocking curtain, and water sprayer is controlled by clicking designated buttons in the manual mode. The IP camera captures and transmits the images of the crop to the mobile device via Wi-Fi. The greenhouse's security is assured by the built-in door reed switch and the alarm device.

As shown in Fig. 1, NodeMcu of the Wi-Fi module links the system to the website programmed in JavaScript. Users can log in to the website to obtain the current values of environmental parameters and view the image of the greenhouse on a mobile device or a PC. Users also can remotely control the system manually or automatically. In the auto mode, the greenhouse's air temperature is controlled within the preset range by operating the ventilation fan and the sunlight-blocking curtain. Air humidity and soil moisture are regulated within the preset ranges by controlling the ventilation fan and the water sprayer. The sunlight-blocking curtain is also operated in accordance with the sunlight intensity. The prototype of the proposed system is shown in Fig. 7, and the user interface on mobile devices is shown in Fig. 8. The images of the greenhouse are sent to the mobile device, as shown in Fig. 9.

3. Discussion

To manage greenhouse farming effectively and save the required manpower and energy, the automated web-based crop system of the greenhouse was developed. The system was connected to the Internet through the WiFi module of the local microcontroller at the greenhouse and

(a) (b)

(c)

Fig. 7. (Color online) Prototype of the proposed system. (a) Side view, (b) front view, and (c) oblique view.

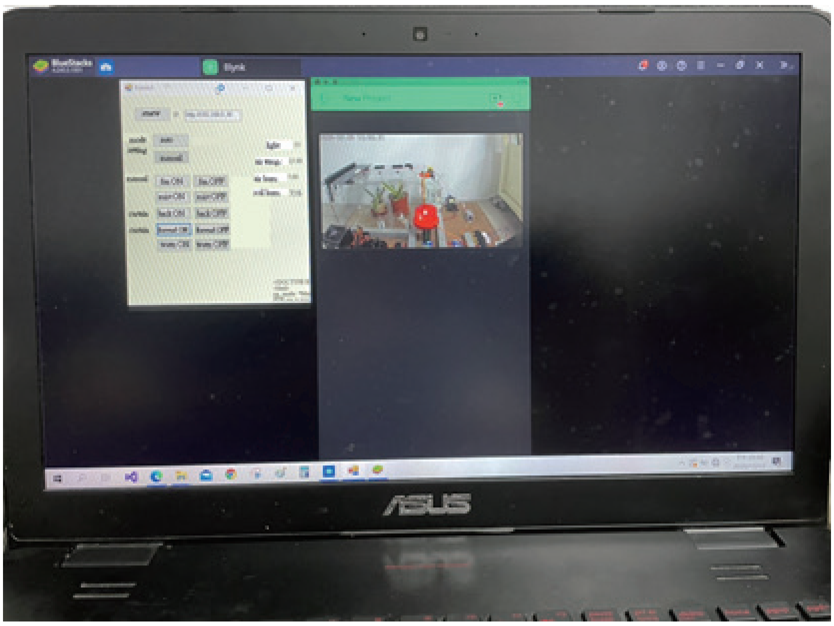

Fig. 8. (Color online) User interface of the proposed system on a PC.

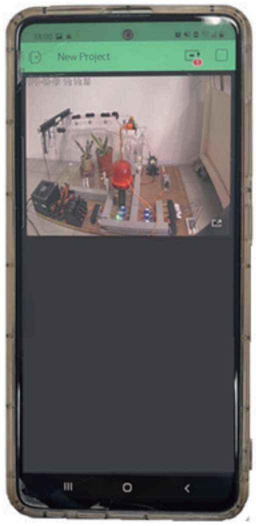

Fig. 9. (Color online) Picture on a mobile device.

controlled on the webpage. In the automatic mode, the local microcontroller adjusted the environmental parameters including temperature and humidity by operating the sunlight-blocking curtain, ventilation/cooling fan, water sprayers, and alarm according to the preset values of the parameters. The manual mode was also available to control the parameters by operating the devices of the greenhouse. The system was equipped with an IP camera that showed the greenhouse on mobile devices in real time. The security system of the greenhouse detected the unexpected opening of its gates and activated the alarm. A prototype of the web-based crop system was constructed in this research, and the test results showed that the above functions were operated successfully and that the automated management of greenhouse farming was performed as designed. Though a scaled-up system for a real greenhouse is necessary to ensure the operation of the web-based crop system, the system allows the efficient and effective management of greenhouse farming to reduce the cost of farming and increase productivity.

4. Conclusions

We proposed a web-based crop system to increase crop productivity and improve the environment for growing crops in a greenhouse. The system uses four sensors to monitor environmental parameters such as air temperature, air and soil moisture, and sunlight intensity. Actuators for operating the ventilation fan, water sprayers, and sunlight-blocking curtain are also adopted to regulate the parameters in the preset ranges. To ensure the security of the greenhouse, a reed switch in conjunction with an alarm device is installed. The online image of the crop is taken with an IP camera and transmitted to the remote server (a PC) or the mobile device of the user. The user can log in to the website made with NodeMcu by inputting the system's IP address to view the environmental parameters and images, and control the operation of the actuators if necessary. The web-based crop system can be used to monitor and control the environmental parameters to realize the efficient and effective growth of crops.

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