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Smart Green House using Wireless Sensor Network

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***Abstract*—Nowadays, the greenhouse is applied widely in the countryside to plant crops or vegetables for the whole year regardless of the seasons. Most of the greenhouses utilized electromechanical devices such as thermostats to monitor and control the environment. The fundamental idea of this research work is integrating the modern technology in the current agricultural practices in order to achieve better yield. The objective of this paper is to propose smart greenhouse system at low cost, which is designed by integrating temperature sensor, soil moisture sensor and light detector resistance ~~and~~ to wireless sensor node. The sensors will be used to measure the surrounding temperature, soil humidity and light intensity inside the greenhouse, and transmit these sensing data to where the action will be taken. The wireless sensor node consists of wireless transceiver module and programmable Arduino uno microcontroller board. The sensing data are received in near real time through wireless communication node for display, maintain and control the inner climate of the greenhouse through irrigation system, fan and the required devices.. During wireless transmission data may get corrupted. To avoid this, error detection codes have been used to help detect if any error has occurred during transmission. The project prototype has been tested, and the results show that the designed system works efficiently in monitoring greenhouse environment.**

Keywords—Greenhouse, Wireless Sensor Network, temperature sensor, soil moisture sensor, light detector resistance

I. INTRODUCTION

The climate uncertainties have led to severe food shortage and starvation. One possible solution to achieving food security is to use greenhouses, which enable the farmer to control the growth conditions thereby ensuring maximum crop yield throughout the year.

In the past, the greenhouses utilized electromechanical devices such as thermostats to monitor and control the environment. Mechanical systems lack the flexibility and precision required for greenhouse control. Over the years, with the rise of smart technology, the need to reduce water resources consumption and power consumption has increased, both with reducing human efforts in agriculture. In addition, smart irrigation systems and smart greenhouse studies have accelerated in order to meet the increasing food demands with the effect of population growth and to support farmers in order to grow quality products in economic conditions[1, 2]. The efficient monitoring and control of the climatic environment in a greenhouse is very important for protecting crops from inconvenient environments. Many sensors and actuators are used to control the system in the large-scale greenhouses. The manual monitoring and control of such big systems are very difficult and impractical. Thus, automatic monitoring and control systems in the greenhouses have become more popular. The smart greenhouse is a revolution in agriculture, creating a self-regulating, microclimate suitable for plant growth through the use of sensors, actuators and monitoring and control systems that optimise growth conditions and automate the growing process. In this work, a smart greenhouse system model has been designed and implemented that automatically monitors and controls greenhouse parameters and maintains them within the predefined optimum range. The designed model will helps the farmers to carry out the work in a farm automatically without the use of much manual inspection. Different plants require different amount of soil moisture, humidity, temperature and light intensity, and lack of awareness of this information or negligence of a person cultivating land can cause plants to die before maturing [3]. The paper is organized as follow, section II present literature review on current technology used to build smart greenhouse, proposed smart greenhouse model is presented in section III, results and discussion are presented in section IV, conclusion is presented in section V.

II. RELATED WORK

Smart technologies play a crucial role in economic growth. They transform houses, offices, factories, and even cities into autonomic, self-controlled systems without human intervention. Parameters such as soil moisture, light intensity and temperature are measured and controlled inside greenhouse in order to push towards automation increase productivity in agriculture. This section includes a review of some of these systems that are designed for this purpose. GSM-based greenhouse system was developed for agricultural field. The controlling unit comprised of ARM microcontroller. Number of sensors is used to measure light intensity, humidity and temperature levels. The output unit comprised of LCD, personal computer, GSM and actuators [4]. In [5], Microcontroller based automatic greenhouse prototype was designed. The sensing unit comprised of sensors for measuring humidity and temperature and measuring soil moisture. The central unit comprised of a personal computer, USB cable and 19200 baud 2.4 GHz RF modem. In [6], microcontroller-based prototype to monitor and control greenhouse parameters using sensors, SMS technology and Bluetooth signals has been designed and implemented. The Bluetooth and GSM based remote wireless automatic monitoring system provide mobility during the monitoring and control process. Short Message service (SMS) is a very popular means of communication. The only disadvantage is that delivery of messages in real time depends on the phone's network reception. In this work two Wireless sensor nodes are used, one node is used to measure the inner climate parameters inside the greenhouse, while the other node will be used to control fan, the irrigation system and display the inner climate parameters.

III. The Proposed Smart Greenhouse System

A. Hardware Design

The smart greenhouse system prototype has been buildup using two wireless sensor nodes. Fig. 1 shows the block diagram of the proposed system. The first node consists of the following units: Temperature and humidity sensor (DHT11), Soil Moisture Sensor, light intensity sensor (LDR), Arduino Uno Microcontroller board (ATmega328P), RF wireless transmitter module (NRF24L01) and power supply. The microcontroller was interfaced with these three sensors to measure inner climate parameters inside the greenhouse which include, temperature, soil humidity and light intensity. Fig. 2 shows the sensing elements that have been used.

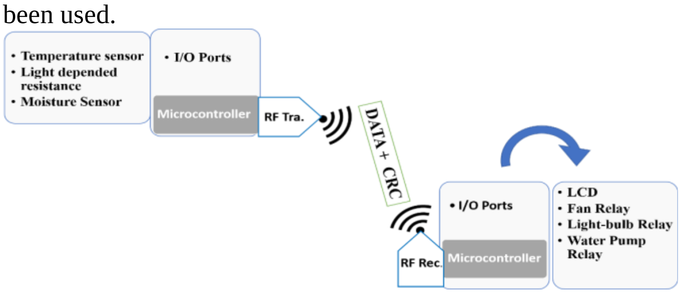

Fig. 1. Block diagram of the Proposed Greenhouse System.

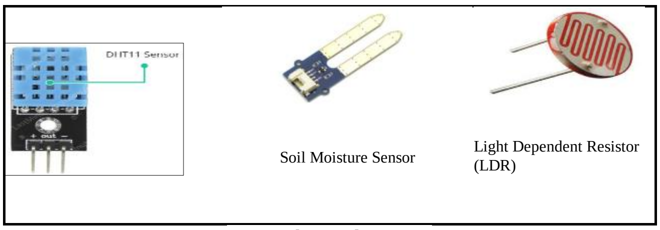

Fig. 2 The used Sensors

The following figures show how the sensors, the wireless communication module, and an LCD interface with Arduino

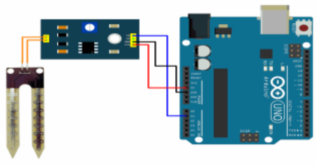

Fig. 3 Interfacing Soil Moisture Sensor with Arduino

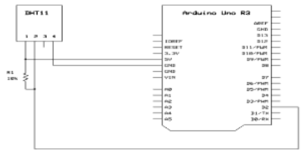

Fig. 4 Interfacing DHT11 to Arduino

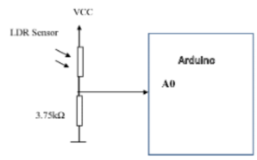

Fig. 5 Interfacing LDR to Arduino

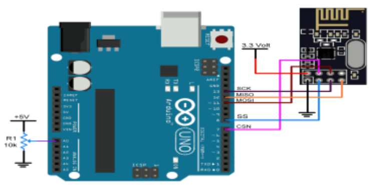

Fig. 6 Interfacing wireless communication module with Arduino

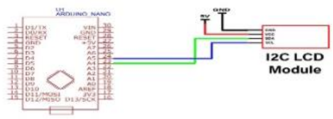

Fig.7 Interfacing an I2C LCD with Arduino

The data obtained from the sensors was fed to the microcontroller, which in turn transmitted the sensed data with error correction code via RF transmitter to the second node (Control node). The second node comprises of Arduino Uno, RF receiver module, LCD I2C display and three relays. The node has been equipped with error detection protocol to ensure correctly receiving of sensed reading that has been transmitted by the first node. Depending on the values of receiving data decision will be made by microcontroller to switch on or off the three relays which are attached to the fan, water valve and light bulb. The Crystal LCD display that has been interfaced to the Arduino will be used to display the temperature, soil moisture and light intensity.

The basic duty of the 12 V fan was to propagate the heat in the greenhouse in a way that did not harm the plants. 12 V water pump was utilized in the irrigation system. It was designed in a way that the water rising by this pump would irrigate the whole of the soil areas with the hose. As well as a ceramic heater lamp can be utilized together with fan to distribute the heat inside the greenhouse.

B. Software Design

The greenhouse system has been developed based on two wireless sensor nodes. Therefore, two programs need to be developed and uploaded to each of the wireless sensor nodes.

B1. Program the Arduino UNO MCU in node 1

The following steps were applied in order for the first wireless sensor node to operate effectively as shown in Fig.3:

A. Start: the Arduino IDE software should be running
B. Reset the microcontroller for node 1 to be ready to execute the instructions.
C. Initialize the sensors and wireless communication module, this required installing of the DHT library for temperature sensor and R24 library for wireless communication module in the Arduino directory.
D. Read the DHT11, soil moisture and LDR sensors.
E. Transmit the temperature, value of soil moisture, value of the light intensity and CRC for error detection.

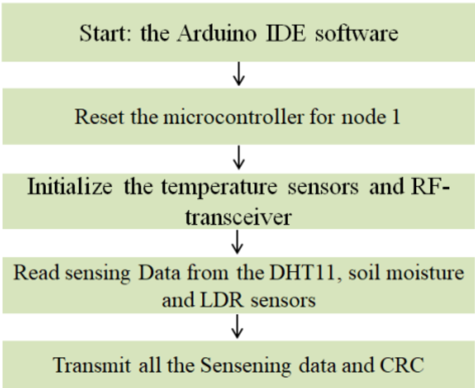

Fig. 8 Flowchart Program the Arduino UNO MCU in node 1

B.2 Program the Arduino uno MCU in node 2

The following steps that were applied in order for the second wireless sensor node to operate effectively as shown in Fig.4:

A. Reset the microcontroller for node 2 to be ready to execute the instructions
B. Initialize the Liquid Crystal displays (LCD) and wireless communication module, this required installing of a library called LiquidCrystal_I2C in the Arduino directory. This library is an improved version of the Liquid Crystal library that comes packaged with your Arduino IDE.
C. The receiver part of NRT 24 communication module receiver the sensing data that has been transmitted by the first node.
D. The microcontroller check if the received data has been received correctly, by calculate the CRC and compared with the received CRC value. If both values are identical then no error and action by microcontroller should be taken.
E. The received sensors reading will be display on LCD.
F. If the temperature is greater than 25C temperature then the turn on the fan, otherwise turn off.
G. If the value of soil moisture is less than 900, the water pump is turn on otherwise turn off.
H. If the value of light intensity is less than 160, the light bulb is turn on otherwise turn off.

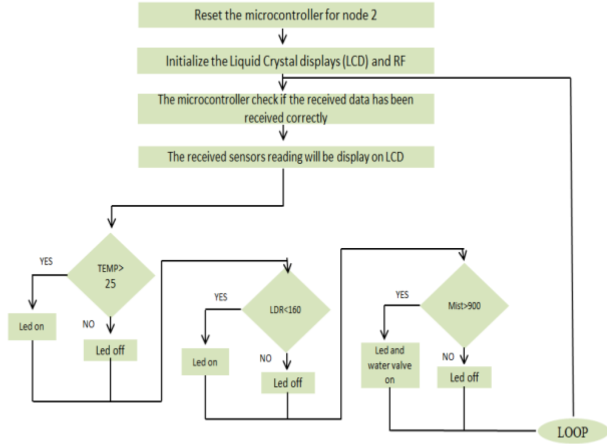

Fig. 9 Flowchart of programming the Arduino UNO MCU in node 2

IV. RESULTS AND DISCUSSION

The complete smart greenhouse model which includes two wireless sensor nodes and the controlled devices were tested. Three relays named have been used to control the fan, water pump and light bulb. Fig.5 shows Green House System prototype. After confirmation of each program proper working, all these programs were integrated to form one comprehensive program to operate the whole greenhouse model. The integrated program was uploaded to the Arduino ATmega328 Microcontroller.

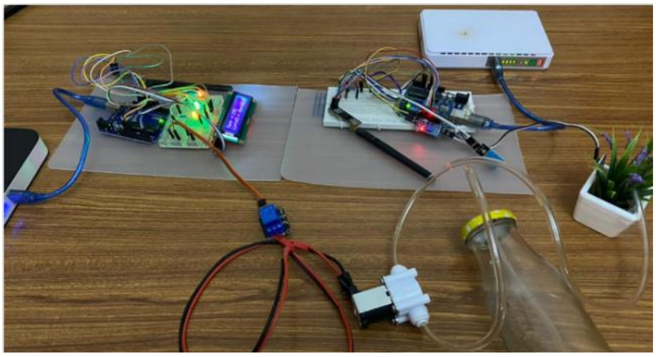

Fig. 10 Smart Green House System prototype

Once the program was uploaded, and the LDR was subjected to darkness by covering it with a paper, the light pulb switched on since the light intensity below light threshold 160. Table 1 shows several readings of light intensity that are measured in node 1 and transmitted to node 2 (Control node).

Table 1 Testing the LDR Sensor

LDR Reading	Condition	Light Pulb
281	Day light	off
282	Day light	off
160	Threshold	off
123	Dark	On
131	Dark	On
142	Dark	On

The soil moisture sensor has been used to measure the soil state. If the value of soil moisture above 999, the water pumb will be switched on. Table 2 shows several soil moisture sensor readings that received intensity that are measured in node 1 and transmitted to node 2

Table 2. Testing Results of the Soil Moisture sensor

Sensor Output	Soil State	Water Pumb
1022	Dry	Switch On
1022	Dry	Switch On
1022	Dry	Switch On
941	Wet soil	Switch off
935	Wet soil	Switch off
567	Wet soil	Switch off
480	Wet soil	Switch off
467	Wet soil	Switch off

The system has been tested in different room temperature, the fan is off when the temperature below 25, and it is On when the temperature above 25. Table 3 shows the testing Results of DHT11 sensor.

Table 3 Testing Results of DHT11

Temperature	Condition	Action
23	LED off	Fan Off
25	Threshold LED on	Fan On
26	LED on	Fan On
27	LED on	Fan On
29	LED on	Fan On

Fig. 5 shows the value of temperature (Temp), light intensity (Li) and soil moisture (Mo) haven been displayed on Liquid Crystal Display after receiving in node 2.

Fig.11. LCD displays the value of measured temperature, light intensity and soil moisture.

V. Conclusion

The advantage of Smart Greenhouse over conventional farming is that we were able to create a climate for the proper growth of plants at low cost and low power. Implementation of such a system in the field can definitely help to improve the yield of the crops and aids to manage the water resources effectively reducing the wastage. This work can be improvised by using a sensor to note the soil ph value such that usage of unnecessary fertilizers can be reduced. A water meter can be installed to estimate the amount of water used for irrigation, The project protype has been tested under different climate conditions in terms of Light and tempreture, and the results show that the designed system works efficiently in monitoring greenhouse environment. The proposed system can be improved by using more wireless sensor nodes for large area of greenhouse. In addition, The farmer can be notified of actions made in the greenhouse either by sending an SMS or developing a mobile application.

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