AUTOMATIC CONTROL OF HYDROPONIC CULTIVATION USING IOT

P Veera Swamy[1]
Asst.Prof, Dept of ECE DIET, Vijayawada, India.

Jannu Chaitanya[2]
Lecturer, Dept of ECE, DIET, Vijayawada, India.

K Goutam Kumar[3]
Department of ECE, DIET, Vijayawada, India,

Ch Kavita[4]
Department of ECE, DIET, Vijayawada, India,

Asfia Shireen[5]
Department of ECE, DIET, Vijayawada, India,

K Hema Sri[6]
Department of ECE, DIET, Vijayawada, India,

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Abstract— This project demonstrates automatic irrigation system with integrated multiple sensors like LDR, temperature, pH & air flow sensors. This project is best suited for indoor drip irrigation technique. Wi-Fi based IOT technology is used here for wireless communication with farmer. The design is created can monitor important parameters in the hydroponic cultivation system such as Light intensity, Room temperature, humidity , Acidity of nutrient solution and air breeze. The prototype is designed using Arduino UNO that connects directly with sensors. It also sends sensor data and status, collects pH values of individual nutrient solution tank, and sends notification via Android mobile application. The data history is available on web application. This therefore is easily to monitor, manage data, and setting online. The evaluated results show that the system can decide the results from multi-sensor grouping as the setting correctly.

Keywords — Hydroponic Cultivation, Internet of Things (IOT), Mobile application.

I. INTRODUCTION

Healthy eating tends to continue popular due to a number of health-aware customers so that the demand for hydroponic vegetables become growing. In order to increase trade competitiveness of hydroponic market, farmers should grow the hydroponic vegetables in tropical climate smartly to provide high quality and yield.

Most of the vegetables, for example, green oak, butter head, red coral, fillie iceburg, red oak, and cos are planted for salad in farm-to-table restaurants, supermarkets, and hypermarkets that require safe food. Nutrient film technique (NFT) is a popular commercial hydroponic system in tropical countries, especially in Thailand. NFT grows plants by pumping nutrient solution through channels constantly from the main reservoir/tank like a re-circulating system. Plants therefore need only water and nutrient to grow. In order to grow qualified vegetables in Thailand, we have to qualify to Good Agricultural Practice (GAP) for food safety.

Accordingly, we need to control factors related to tropical plant growth and GAP qualification. The hydroponic cultivation should control humidity, water level, pH, and EC suitable for climate and control nutrient solution in the tank as safely as possible to GAP qualification. In addition, power outage should be monitored to avoid water pump failure. To improve yield and control factors efficiently, Internet of Things (IoT) are applied for send and receive sensor data online, and analyze the data for precision farming [1].

Nowadays, researchers focus on controlling and managing big data in smart farming [2]. To control and manage the data, we have to concern about raw data and information suitable for analyzing as the purpose and decision making. Some of them develop irrigation management system using wireless sensor networks (WSN) for precision farming [3]-[7]. In hydroponic precision farming, pH and nutrient solution in the main reservoir are automatically controlled throughout 24 hours by calibrating sensors and measuring nutrient solution in order to increase productivity and reduce labor [8] – [9]. However, in tropical countries such as Thailand, weather is normally hot and high humidity for the majority of the country during most of the year. The NFT hydroponic vegetables require suitable temperature and humidity in the greenhouse. Hydroponic system also requires water and air pumps to flow the nutrient solution into the channels almost all the time, therefore it needs reminder when power outage occurs. Moreover, the tropical hydroponic cultivation needs to control nutrient solution temperature suitable for root growth during hot weather. Normally, the tropical cultivation has more disease then other climates; thus, nutrient solution should be separated in different tanks to be available to grow variety vegetable ages, plants, and to control disease easily. In Thailand, the solution has to be controlled pH and EC values as the GAP qualification. Therefore, multisensor data fusion is important to arrange in order to maintain accurately decision results.

This paper proposes an automatic control and management system for tropical hydroponic cultivation. The system can control factors suitable for a various kind of vegetables in different nutrient solution tanks automatically by using Internet of Things (IoT) as wireless sensors. The power status, temperature, humidity, water level, pH, and EC data are sent to database. The system can control water level automatically as the user setting in different tanks by pairing ultrasonic sensor with solenoid valve. For the temperature and humidity control, we pair the SHT31 sensor with foggy solenoid valve. The proposed system is designed to show sensor status, sensor data, and send notification while power outage via Android mobile application. The system is also available to work as automatic and manual modes. The sensors are simply installed. User can connect the sensors with wi-fi and then add them directly via mobile application. It therefore is easily to monitor, control, and set data online as the user requirement, and reduce installation cost. In addition, we can use the data collected in the database to analyze and improve hydroponic vegetable growing in different seasons efficiently.

II. LITERATURE SURVEY

- K. Al-Kodmany, **"The vertical farm: A review of developments and implications for the vertical city"** they have discusses the emerging need for vertical farms by examining issues related to food security, urban population growth, farmland shortages, food miles.

- Helmy, Marsha Gresia Mahaidayu, Arif Nursyahid, Thomas Agung Setyawan, Abu Hasan – 2017, In their paper **"Nutrient Film Technique (NFT) Hydroponic Monitoring System Based on Wireless Sensor Nutrient"** they have proposed the usage of pH sensor for the purpose measuring nutrient level in the water solution.[1]

- Robert Eko Noegroho Sisyanto, Suhardi, Novianto Budi Kurniawan – 2017, In their paper **"Smart farming using cyber physical social system with telegram messenger"** they have proposed that the sensor data can be transmitted as a message.[5]

- Siwakorn Jindarat, Pongpisitt Wuttidittachotti-2015, **"Smart Farm Monitoring Using Raspberry Pi and Arduino"**,they have proposed the usage of arduino in smart farming.[4]

- Francesco Fabiano Montesanoa, Marc W. van Iersel, Francesca Boari, Vito Cantore, Giulio D'Amato, Angelo Parente- 2018, **"Sensor-based irrigation management of soilless basil using a new smart irrigation system"**, they have proposed sensors can be used for monitoring irrigation.[7]

- N.Watthanawisuth, A.Tuantranont, and T.Kerdcharoen- 2009, **"Microclimate real-time monitoring based on ZigBee sensor network"**, they have proposed that ZigBee is used to monitor the hydrosponic environment, according to the climate change and it turn on/off the LED lights.

- Muhammad Agus Triawan-2016,**"Internet of Things using Publish and Subscribe Method Cloud-based Application to NFT-based Hydroponic System"**, they have proposed cloud based application for the purpose of accessing and monitoring the system using cloud technology.

- K. Al-Kodmany, **"The vertical farm: A review of developments and implications for the vertical city"** they have discusses the emerging need for vertical farms by examining issues related to food security, urban population growth, farmland shortages, food miles.

- S. Ruengittinun, S. Phongsamsuan, Sureeratanakorn, " Applied Internet of Thing forSmart Hydroponic Farming Ecosystem (HFE)&quot, in this they proposed hydroponic system to bring in another technological advancement by breaking all barriers, for organic farming is the Hydroponics where consumption of space and water are way too minimal.

III. AUTOMATIC CONTROL OF HYDROPONIC CULTIVATION USING IOT

This paper presents the automatic control of hydroponic cultivation. The system is divided into 3 processes: sensor node, sensor with data fusion, and data fusion result. In this sensor node process, we get the raw monitoring data from the sensors and then send the data to the sensor with data fusion process. Afterwards, we integrate sensor data from various sources in sensor with data fusion process. This may provide data redundancy due to individual overlapping sensor data. In order to reduce data redundancy, the proposed system allows users to pair or group the sensors that can work together to decide the efficient results in data fusion result process. This provides multisensory data fusion reduction so that we can make decision result accurately. In addition, the users can set sensor data as the condition for data fusion result via mobile application.

A **Light Dependent Resistor** (LDR) or a **Photo resistor** is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells. As the light intensity decreases, it will turn on led.

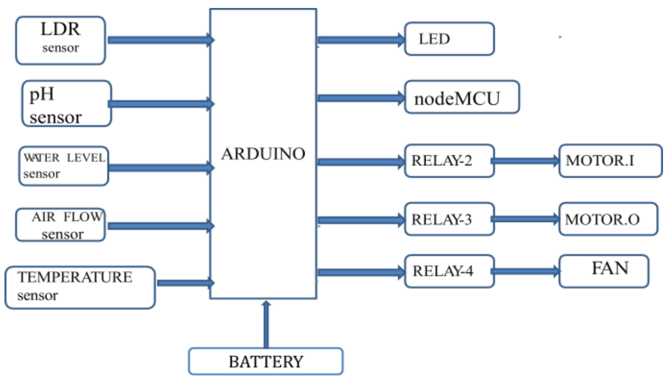

Fig. Block Diagram

A **pH** meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as **pH**.

A **float switch** is a type of **level sensor**, a device used to detect the **level** of liquid within a tank. The **switch** may be used to control a pump, as an indicator, an alarm, or to control other devices.

The air flow or breeze detection sensor is used to sense the breeze runing in the indoor environment and if it is low than the standard value it will turn on the FAN.

Temperature Sensors measure the amount of heat energy or even coldness that is generated by an object or system, allowing us to "sense" or detect any physical change to that **temperature** producing either an analogue or digital output.

The **Arduino Uno** is a **microcontroller** board based on the ATmega328 (datasheet). It has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

nodeMCU is an open-source firmware and development kit that helps you to prototype or build IoT product. It includes firmware which runs on the **ESP8266** Wi-Fi SoC from

This is available to apply the sensor to variety hydroponic plants or Fig. 1 shows sensor nodes. There are 5 sensor nodes, they are objectives LDR sensor, water level sensor, air flow sensor, pH sensor, and Temperature sensor. The sensor nodes then send their raw monitoring data to sensor with data fusion process (DFI).

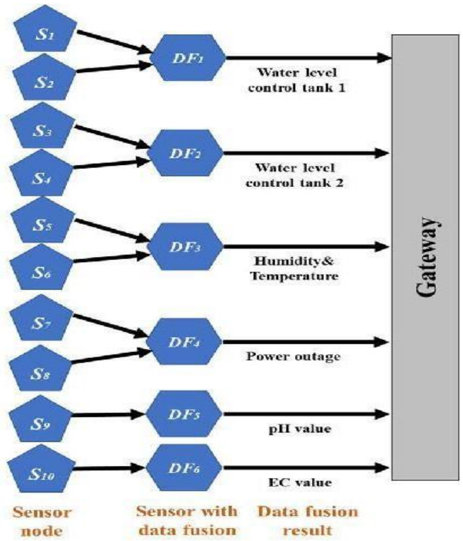

Fig. 1. Overview of data fusion management for automatic control and management system for tropical hydroponic cultivation

The automatic control and management system for tropical hydroponic cultivation can be access via mobile application and web application. The results of the application are described as follows:

A. Sensors installation

Fig. 2. Sensor installation (a) foggy solenoid valve (b) humidity and temperature sensor (c) water level sensor

The proposed sensors are installed at northern Thailand hydroponic farm as shown in Fig. 2. There are 6 sets of sensors installed: a set of pH sensor, EC sensor, power outage detection, humidity and temperature sensor, and 2 sets of water level control. The power outage detection sensor is divided into wireless transmitter and wireless receiver. The transmitter plugs in at the power socket and the receiver plugs in at the UPS. The humidity and temperature sensor is paired with foggy solenoid valve. The 2 ultrasonic sensors are grouped with water level solenoid valve in tank 1 and tank 2, respectively. The EC and pH sensors are rechargeable via the built-in lithium polymer batteries. This makes the EC and pH sensors portable. All of the sensors connect to the same internet gateway without data interference because the sensors are grouped to decide the efficient results in data fusion result process.

B. Mobile Application

In the Android mobile application, users can log in to the application using Facebook account or register for the new account in Fig. 3(a). To use the automatic control and management system, we have to add sensor device as the plus icon '+' in Fig. 3(b). We can match the sensors as group of sensors or add individual sensor by scanning QR code or filling up the sensor ID shown in Fig. 3(c)

Fig. 3. Android application result (a) log in page (b) add device (c) add device using QR code or sensor ID

Humidity and temperature sensors can be accessed by clicking on individual tab and then choose the automatic or manual foggy solenoid valve control in Fig. 4 (a). If automatic system is chosen, the valve will switch on when the humidity is less than 25% then the valve will switch off when the humidity is equal 28% automatically. For the EC and pH monitoring, the users can access to individual tab and then they click on the sensor that they need to observe. The EC and pH values of each tank can be displayed sensor history on 'view record' button. We can record the EC and pH values separately of each nutrient solution tank by clicking 'record' button shown in Fig. 4 (b).

Fig. 4. Individual sensor page on Android application (a) humidity and temperature monitoring (b) EC and pH monitoring.

To set the water level of each tank, the users have to enter the height, width, and length of the tank so that the system estimate the tank volume shown in Fig. 5 (a). Afterwards, the water level scale can be set the percentage of minimum and maximum water level left in the tank. We can select 'manual adjust' or 'auto adjust' menu. If manual adjust is selected, the users have to adjust the level percentage in Fig. 5 (b). On the other hand, if the auto adjust is chosen, the user just put the water into the tank as the level that they need. Then, the system records this level as the system setting. This paper sets water level manually at the level 30%-80% of the tanks. If the water level is lower than 30% of the tank, solenoid valve will switch on until the water level is equal to 80%. The results of water level monitoring on mobile application is shown in Fig. 5 (c).

Fig. 5. Android application result (a) tank volume estimation (b) water level adjustment (c) water level monitoring

IV. RESULTS & DISCUSSION

In the Table.1, we have shown the standard values to be maintained in the hydroponic cultivation like pH that means acidity of the nutrient solution, Electric Conductivity[EC], Room Temperature and the Light Intensity.

Table.I Standard Values

pH	5.8-6.3
EC	1.2-2.0

Temperature	18-26 °C
Light	400-600 W

The sensors can send data correctly and as fast as real time processing to the Arduino UNO and it will uploads the data to the cloud using WI-FI module. The user can access the sensor data present in the cloud by using Blynk application. However, the EC and pH sensors are bigger than the conventional offline equipment and they need high power for proper working.

V. CONCLUSION & FUTURE SCOPE

This paper proposes automatic control and management system for tropical hydroponic cultivation to reduce information exchange of multi-sensor data fusion within the wireless sensor network. The system provides sensor grouping to decide the data fusion results without data interference. The system can control water level, humidity, and temperature as grower setting both automatically or manually. It sends sensor data, sensor status, and notification via Android mobile application meanwhile the sensor data history is available on web application. This therefore is easily to monitor, manage data, and set the system online. The system is tested by hydroponic grower in northern Thailand hydroponic farm. The evaluated results show that the system provides the results as the setting correctly. It presents stable connectivity and durable as the portable equipment.

Many IOT enabled hydroponic farms such as rooftop farms, vertical farms and green buildings can be placed near the city areas which will directly cut transportation costs & using IOT plants can be transported safely. A standard website can be made which will take sensor data place correct graphs and help farmers to attain information. This way every farm will be used for research purposes. Government, big co-operations will jump into hydroponics because of low arable land, availability of water, costs, climate change and increasing population.

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