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Automated Planter System for Urban Area using IoT Technology

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Abstract: Large varieties of smart automatic watering systems have been introduced to support the development of urban agriculture. However, these systems are still not included the action to apply fertilizer which is significant to boost the overall growth of plants. This paper presents the development of an automatic planter system to monitor urban area farming, control the fertilizer mixing process and regulate the watering process. The system is implemented by integrating a typical farming system with a web interface to monitor the farm condition. Electrical conductivity (EC) sensor probes are adopted to monitor EC value and determine an appropriate nutrient solution to be supplied to the plant. To produce a nutrient solution with specific EC, the amount of water and nutrient solution volume are calibrated using the linear-plot method. The system is then tested to produce a nutrient solution with desired EC value. The analysis of test results indicate that the system is able to produce a nutrient solution with a specific EC value with a deviation of 0.2 mS/cm.

Keywords: Automatic Planter System, Fertilizer Mixing Process, Watering Systems, IoT

1. Introduction

Urban farming becomes popular recently, as consequence many automatic watering systems and smart controller watering devices are developed [1]. However, these devices and smart systems are unable to mix fertilizer into the water to be provided to the plants. Many researches have shown suitable fertilizer or nutrient solution is able to boost the overall growth of crops. [2-4]

The purpose of designing the planter system is to enable people in the urban areas to plant crops. Besides monitoring the temperature and humidity of the farm environment, the planter system is able to mix specific nutrient solution and deliver nutrient solution to the plants when the moisture level of soil drops below a certain value. In particular, the quantity of nutrition can be measured through EC sensor probe, whereby the EC probe measures the electrical conductivity (EC) value of the nutrient solution. Through calibration and plotting graph, the volume of nutrient solution can be determined and pre-programmed into a microcontroller device.

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In general, water level sensor would be utilized to detect level of nutrient solution in a tank. The nutrient solution actually is a mixer composition of water and fertilizer nutrient that being controlled by the controller unit. If the water is below the designated level, the pump would inject water and fertilizer nutrient into the water tank with a specific duration. With a nutrient solution prepared, the system is ready to water the plant using another pump when the condition is met, which is when the soil of the plant is dry and reaches a low moisture value. Another microcontroller will use DHT22 sensor and EC sensor probes to capture temperature, humidity and EC value for the planter system. These values are sent to the IoT platform and displayed on the User Graphical Interface (GUI).

2. Methodology

2.1 Overview of Planter System

The planter system as shown in Figure 1 consists of two parts: hardware and software. The first Node Microcontroller Unit (NodeMCU) is used to collect temperature, humidity of environment and EC value of the nutrients solution. The data being collected in the first NodeMCU then are sent to the Node-RED dashboard so that the remote monitoring can be achieved. The second NodeMCU is utilized to control two different pumps based on duration of operation. One of the pump is used to pump nutrient solution from main storage tank to plants, while the other pump is used to control plain water volume and concentrated nutrient solutions volume that is pumped into the main storage tank.

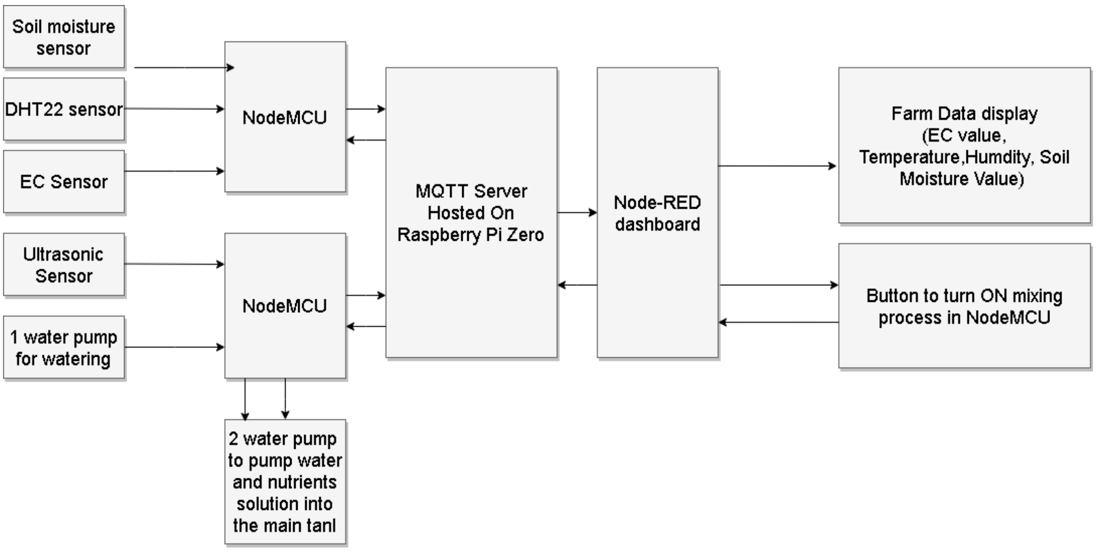

Figure 1: Block diagram of the Planter System

For the software part, it consists of a host MQTT server, which acts as a hub for message communication between the NodeMCUs and the Node-RED dashboard. The dashboard receives data from the server and display on the Node-RED dashboard. There is also a button on the dashboard to start the pump by sending payload to the second NodeMCU through MQTT server.

Several precautions were taken to ensure the hardware part is able to produce consistent results on nutrient solution with the right amount of nutrient concentration (EC value). First, by standardizing the volume of water to be mixed with nutrient solution and the EC value of the concentrated fertilizer solution. The volume of water that is pumped into the main storage tank is 1 liter, and the concentrated nutrient solution has EC value of 5.0 mS/cm. EC value of the mixed solution in the main water storage is taken and recorded for every 100 ml increment of nutrient solution (5.0 mS/cm) pumped and mixed with 1 liter of water.

2.2 Linear Plot of EC Measurement

The method of obtaining a linear plot of EC value of solutions and volume of nutrient solution mixing with water as explained in the previous work [2]. This method indicates that the EC value of solutions increase linearly with fertilizer solution added, thus it is useful to produce nutrient solution with desired EC value for the requested volume of nutrient solution. The y-axis is the measured EC25 (electrical conductivity at 25 C), and the x-axis determines the corresponding nutrient volume to produce nutrient solution with desired EC value.

2.3 System Reliability Test

The fertilizer volume needed to produce nutrient specific value within the range of 0.5mS/cm and 2.5mS/cm and the range value is programmed into NodeMCU. The NodeMCU controls duration the operation of the pump that deliver fertilizer into mixer. Indirectly the needed amount of fertilizer is provided to produce the nutrient solution for desired EC value. The EC measurement value is then compared to the desired EC value to perform reliability test for the system.

3. Results and Analysis

Figure 2 illustrates the NodeMCU is able to send farm environment data to the Node-RED dashboard for monitoring parameters of soil moisture, temperature, and humidity for the farm. The NodeMCU would turn on the pump when the soil moisture value drops below 30%. The EC probe has captured the EC value of the solution in the main storage tank and send the reading to the Node-RED dashboard through the MQTT server. Table 1 shows the measured EC25 value of EC meter and Sensor probe with fertilizer volume.

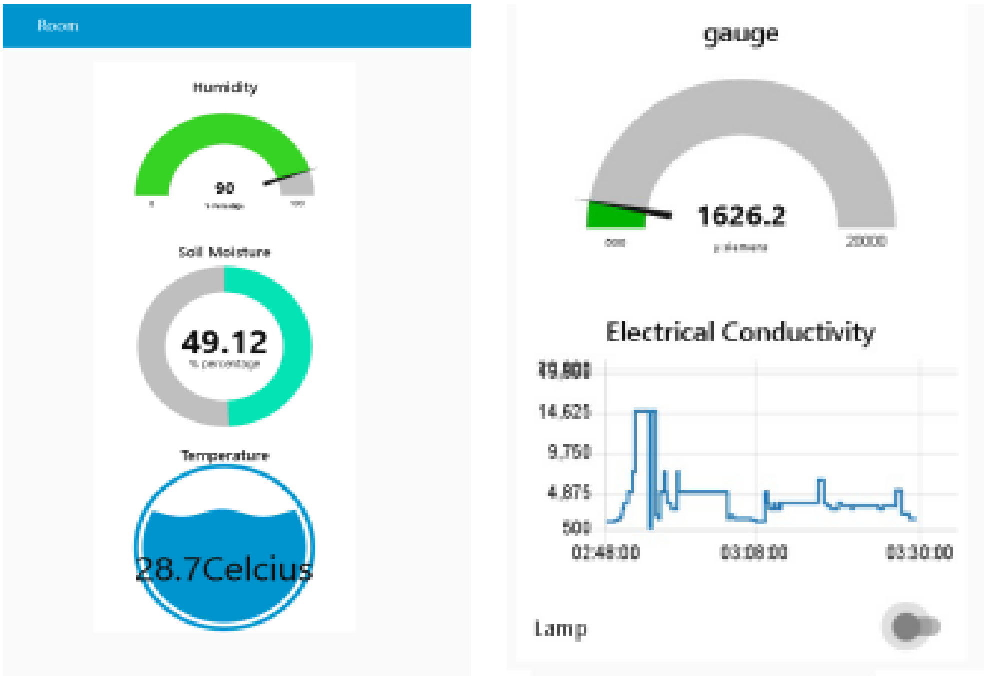

Figure 2: The Node-RED dashboard that shows the farm environment data from NodeMCU

Table 1: Measured EC25 value of EC meter and Sensor probe with fertilizer volume

Fertilizer Volume (ml)	Measure EC25 value (TDS EC meter)	Measure EC25 value (NodeMCU sensor probe)
0	108	153
100	520	602
200	844	928
300	1021	1216
400	1245	1542
500	1383	1721
600	1581	1941
700	1864	2075
800	2122	2176
900	2268	2265
1000	2460	2408

The resultant EC value of solutions is recorded according to the amount of fertilizer solutions added to the main water tank. From the graph in Figure 3, it is possible to estimate the amount of fertilizer solutions needed to produce solutions with specific EC value from the linear plot equation.

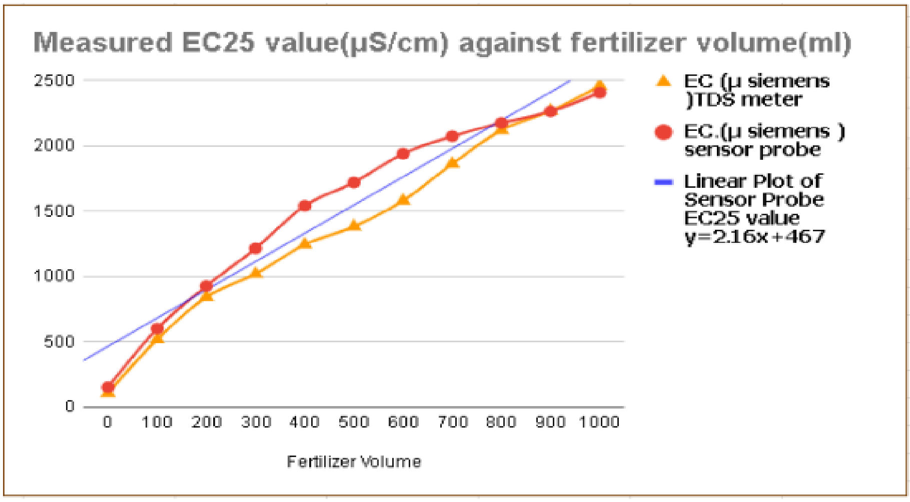

Figure 3: Graphs of EC value against Volume of Nutrient solution

According to [5], the suitable range of EC value for the growth of plants is 1.8 to 2.4mS/cm. Therefore, this range is accepted as reference for testing the mixing part of the system. The desired EC value chosen for setting the system is from 0.5 to 2.5mS/cm with a difference of 0.25mS/cm between each value. For each desired EC value, the system determines the amount of fertilizer needed to be pumped into the main storage tank. The EC value of the mixed solution is recorded in Table 2.

Table 2: Table of collected EC value and deviation from desired EC result

Desired EC Value (mS/cm)	Fertilizer Solution Volume (ml)	EC Value from Sensor Probe (mS/cm)	Deviation from Desired EC
0.50	15	0.25	0.25
0.75	130	0.61	0.14
1.00	245	1.02	0.02
1.25	360	1.38	0.13
1.50	480	1.64	0.14
1.75	595	1.98	0.23
2.00	710	2.11	0.11
2.25	825	2.32	0.07
2.50	940	2.46	0.04

From Table 2, notice that the desired EC value that ranges from 0.50 to 1.00, the corresponding result of the EC value indicating a gradually decreases gap. The deviations at EC value from 0.50 and 1.00 are slowly decrease to 0.25 and 0.02.

The vast deviation is because the use of line-equation method is less reliable to estimate fertilizers needed to produce EC value less than 1.00 mS/cm. The linear plot Y=2.16x+467 estimation assumed the EC value of solutions without fertilizers added to have EC value of 0.46. For EC results that range between 1.00 and 2.50, the deviation is controlled to be under 0.23. The mixing part of the system is tested and have reliability to produce nutrients solution for plant watering within the range of 1.00 and 2.50.

4. Conclusion

As conclusion, the results indicate the objectives of project have been achieved. The project could automatically be mixing and supply the nutrient solution to the plant. The system is also able to produce resultant solution that has a deviation of less than 0.25mS/cm, which the ranges of EC value from 0.5 to 2.5 mS/cm.

Although the linear plot approach is less reliable to estimate the fertilizers needed to produce the desired EC value less than 1.00, but it still manages to produce the solutions with EC value approximate to the desired EC value consistently between 1.00 and 2.50.

Acknowledgement

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