Internet of Things based Nutrition Controlling System Development

Poltak Sihombing, Herriyance, and Eleazar Reymond Gea

***Abstract*—In agriculture, adequate nutrition controlling is essential to manage the fertility of agricultural plants. The main problem in this paper is how to carry out monitoring plant nutrition using sensors, microcontrollers, and smartphones based on the Internet of Things (IoT). Unfortunately, most of nutrition control system still uses the conventional. The objective of this paper is to describe the automatic nutrition control system for smart agriculture. The novelty of this research is the approach of sensor devices used for monitoring agriculture nutrition. To support this research, we use the DFT Deep Flow Technique (DFT) in the hydroponics. The advantage of this method is not only can keep the stability of the nutrient flow but also maintain the nutrition pH level in an ideal position and temperature humidity. We use the IoT technologies to connect the nutrition sensors, microcontrollers, smartphones, and information of the hydroponic plant. The research results that the system can flexibly carry out monitoring the nutrition, water level, and temperature-humidity of the hydroponics area via smartphone.**

***Index Terms*—Control system, internet of things, micro controller, nutrition.**

I. Introduction

THE rapid growth of the Internet of things (IoT) technology, electronics, and smartphones today, resulting in wireless communication is very widely used on the activity of humans life every day.IoT connected devices, sensors, microcontrollers, and other things. Things may include smartphones, sensors, and much more.

In agriculture, especially in hydroponic plants, maintain adequate nutrition, environmental temperature, and humidity, pH (Potential of Hydrogen) of nutrients are very important to manage the fertility of the hydroponic plants. By monitoring environmental temperature and nutrient pH automatically, makes it easy for farmers to control the plant nutrition.

Farmers need tools to support their agriculture and to improve the service of their agricultural needs. IoT has provided agricultural opportunities in several aspects to support the development of agricultural needs services. The development of IoT in various has been driving great interest for us towards the growth of IoT in hydroponics research.

II. Related Work

In previous research related to agriculture, found in Wu, T.H. et. al [1] propose a system that is useful in monitoring data and controlling field operations that provide flexibility. The paper described how to farm smart using IoT technology. An additional feature of the paper is that it involves a Smart Global Positioning System (GPS) based on the remote control for spraying, sensing humidity, and controlling in real-time.

Due to the advance of IoT technology, plant sensors have become a great tool to provide controlling services. Consequently, many modern plant systems use sensors to control plant growth the quality of plants [2].

In some literature, the hydroponics can be used as an alternative to plants in small areas. They describe hydroponic farming and maintain nutritional stability. That is very important if done using automatic nutritional control [3].The another study, David Moriarty has proposed flow device to regulate hydroponic fertility. He proposed the design of electric devices to pump nutrients needed by hydroponics on manually to drain liquid nutrients in hydroponic places [4]. Kameoka, et.al., describes the room temperature measurements for indoor factories by using wireless sensors [5]. In Mark Griffiths [6], developed the hydroponics control system to carry out monitoring of hydroponic growing.

Other related works written by Devika et. al. have described humidity sensors for automatic watering [7]. Another study proposed that the right temperature conditions can maintain hydroponic quality [8].Also, in [9], Sihombing P., et.al., developed the use of Arduino microcontrollers to manage the flow of hydroponic nutrients automatically. It was found that adjusting the pH of nutrients can increase hydroponic fertility. Therefore, nutrient pH needs to be managed by regulating the acidity of nutrients in a closed circuit of fluid flow [10].It is very important to maintain a balance between a pH range so that vegetable products and hydroponic conditions plants can be

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safe for consumption.

M. Guo et al [11], proposed the use of the Internet of Things (IoT) support agriculture. They said that IoT can optimize the nutrition conditions of plants at different times in their life cycle. In [12], Snyder, et al., described the basics of injecting fertilizer for field-grown tomatoes.

The next other works, Baljit et al. have developed nutrients composition control system that automatically monitors EC (electrical conductivity) and pH of soil. They said that the effect of a high concentration of salt and minimize the pH in the soil can do by spreading fertilizers and also will improve productivity [13]. Also, by Wang et al. they wrote that pH and EC (electrical conductivity) are the two important indices of fertility [14]. In de Caritat [15], if the reading is pH 7, it means neutral because of the concentration (H +) and (OH-) are ideal. The pH is obtained from pH = - log [H +] (neg. Log from H + conc.). The pH level gives the number of nutrients in the solution.In another study, Sihombing et al. [16], have developed a tool to manage and control of hydroponics using several sensors and microcontrollers. So far, the use of several sensors and microcontrollers can be said to be very appropriate to help the farmers in hydroponics.

III. Research Method

This section describes the research method of controlling a system for nutrition. We use the DFT (Deep Flow Technique) to support this research. The advantage of this technique is not only can keep the stability of the flow of nutrient but also to maintain the nutrition pH level in an ideal position. A simple diagram is shown in Fig. 1.

A. Simple Diagram of Nutrition Control

The short description as follows:

- The user turns on the system by connecting a Lithium-Ion battery to Arduino and the L289N module.
- The user connects the smartphone with Arduino using Bluetooth or Internet
- pH probe sensor takes the analog value of the hydroponic nutrient.
- Arduino will process and perform calculations based on the analog values resulted from the sensor.
- Arduino sends the value that resulted in the calculation of nutrition pH to the smartphone.
- If the pH value is not around 5.5up to 6.5 scales, the pump should be turned on for adding a nutrient solution by the pH up or pH down pump.
- The LED indicator light will always be turned on since the system start until it is turned off. The LED will turn shut down when the pump starts.

B. Sensor Used

- pH sensor

We used the E201-BNC pH sensor to detects acidity or alkalinity of nutrition. This sensor can measure pH with a very acidic concentration (pH 0) up to a very alkaline solution (pH 14) and can work at -10 up to 50 ˚C a water temperature. Fig. 2 is shown the pH nutrition sensor.

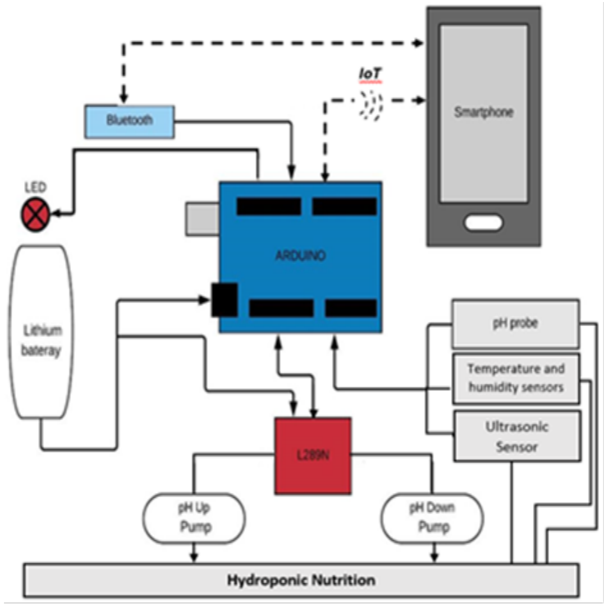

Fig. 1. Simple diagram of IoT and Nutrition Control.

Fig. 2. The E201-BNC pH Sensor.

- Humidity sensor (HSM 20G)

Fig. 3 shows the humidity sensor. This sensor is used to measure not only humidity but also the temperature of hydroponic plants.

Fig. 3. Humidity sensor (HSM20G).

- Ultrasonic Sensor (HC - SR04)

The height of the nutrient liquid in the hydroponics is measured by the HC-SR04 sensor. Fig. 4 shows the HC-SR04 sensor.

Fig. 4. Ultrasonic Sensor (HC - SR04).

IV. Experimental Results and Discussion

A. Software Arduino Uno

To support this research, we have developed the software for Arduino using C programming language and Arduino application as its compiler. The program file from the compiler has an.ino extension which is embedded in the Arduino board.

Fig. 5. A Part of Developed Software of Microcontroller and IoT.

B. Software application developed

We have developed software application by java programming in Android smartphone that serves a piece of information from Arduino microcontrollers. This software application contains an information of pH values from hydroponic nutrients. To operate it, the user must connect the Arduino microcontroller through the smartphone in an internet network or Bluetooth. Fig. 6 shows an example of an experimental set up of hydroponics and software applications in Android smartphones.

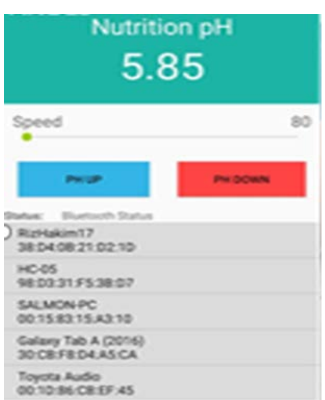

Fig. 6. Nutrition Control in Android by IoT Application.

In fig.6, if the device is connected to a smartphone, the text under the button PH UP will write status: Connected to Device: HC-05. HC-05 is the Bluetooth name of the device. Besides that, there are also two buttons which function are to manually set the on / off-pump. And there is also a seek bar that functions to regulate the speed of the nutrition pump.

C. The pH controlling set up

Fig.7a shows the pH control device, and Fig. 7b shows the pH control device is being tested on hydroponic. We then compare test results of pH sensor (automatic) to pH meters (as manual). The comparison resulted as shown in table1.

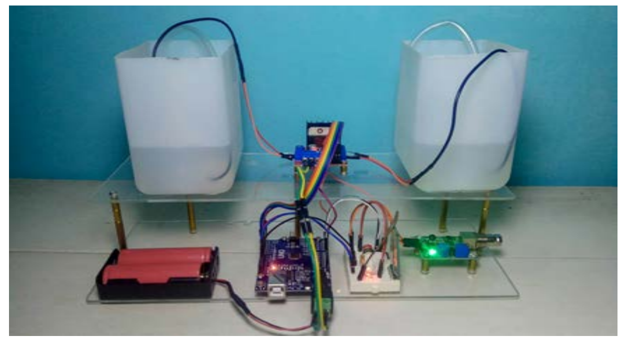

Fig. 7a. The pH control device.

Fig. 7b. the pH control device is being tested.

Figure 7a is an apparatus that has been developed with a microcontroller that functions to control the pH of plant nutrients to remain at pH values start from 5.5 to 6.5. This tool will work automatically and can be controlled from an IoT-based Android.

TABLE I
HYDROPONICS MONITORING BY IOT

Hydroponic Monitoring of Nutrition pH			
No	Time (Hour)	pH meter (Manual)	pH sensor (Automatic)
1	11.00	5.7	5.9
2	12.00	6.2	6.3
3	13.00	6.3	6.5
4	14.00	6.3	6.1
5	15.00	6.2	6.2
6	16.00	6.3	6.0
7	17.00	6.2	6.4

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8	18.00	6.2	6.1

In Table I, the monitoring carried out at 08.00 a.m. up to 07.00 p.m. showed that the detection using a pH sensor (automatic) detection device was almost the same as the test results with a pH meter (manual). The difference from the pH calculation data by manual and automatic methods ranges from 0.1 to 0.3. The results of this monitoring are also shown in fig.8.

A method for calculating pH value is done by the following equation:

pH = - log [H +] (neg. log of the H + conc.),
is reduced to pH = y with the following equation:
$y = -6.159536842x + 24.74252632;$
where y = pH nutrient value, x = ADC value and Constanta (conc.) value = 24,74252632. The value of 5 is the maximum voltage of the sensor, and the maximum value of ADC is 1023. The calculation example of y values is described follows:

$x1 = (ADC * 5) / 1023$
$x1 = (594 * 5) / 1023$
$x1 = 2.903225806$
$(x1, y1) = (2.903225806, 6.86)$
$x2 = (ADC * 5) / 1023$
$x2 = (689 * 5) / 1023$
$x2 = 3.367546432$
$(x2, y2) = (3.367546432, 4)$

The calculation of linear equations is as follows:
$(y-y1) / (y2-y1) = (x-x1) / (x2-x1)$

$(y-6.86) / (4-6.86) = (x-2.903225806) / (3.367546432 - 2.903225806)$
$(y-6.86) / (- 2.86) = (x-2.903225806) / 0.464320626$
$0.464320626 (y-6.86) = - 2,86 (x-2.903225806)$
$0.464320626y-3.185239492 = -2.86x + 8.303225806$
$0.464320626y = -2.86x + 8.303225806 + 3.185239492$
$0.464320626y = -2.86x + 11.4884653$
$y = -6.159536842x + 24.74252632.$

By the description above the value y = pH will be obtained by knowing the measure of ADC value resulted at that time. The detection results by the ADC will be converted into the pH of nutrients automatically by the system. The comparison of pH sensor (automatic) and pH meter (manual) is shown in Fig. 8.

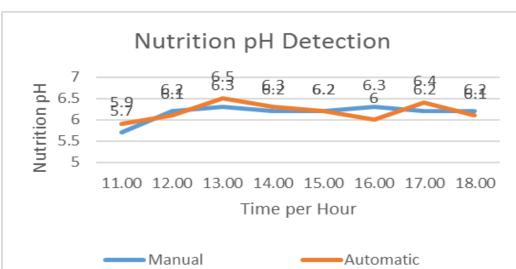

Fig. 8. Nutrition pH Detection.

Table 2 is shown a number of tests of the temperature and height of water resulted from sensors and microcontrollers through a smartphone. For 5 times of temperature tests, we got the average is 28,426 ° C.

TABLE II
TEMPERATURE DATA RESULTED

Number of tests	Time	Data in Android App		
		Temperature	Height of water (Cm)	Delay/ Second
1	06.00	27.30°C	0	5
2	12.00	34.41°C	5	6
3	18.00	29.20°C	4	4
4	00.00	25.10°C	5	2
5	06.00	26.12°C	5	4

The height of water in a hydroponic tube (pipe) is determined as high as 6 cm.If the water height has decreased, then the sensor will report and automatically the water pump will turn on in order to increase the water level on the nutrient tube.

In water height monitoring, we used ultrasonic sensors as the main component to determine the flow of nutrition. Ultrasonicsensor work based on electrical quantities. The result of sensor detection is described in the Table III.

TABLE III
THE WATER HEIGHT MONITORING RESULTED

Number of tests	Time	Height (Cm)	Information
1	06.00	0	The water in the pipe is empty, then the pump turns on
2	12.00	5	The sensor detects water height was 5 cm in the tube.
3	18.00	4	The sensor detects water height was 4 cm in the tube.
4	00.00	5	The sensor detects water height was 5 cm in the tube.
5	06.00	5	The sensor detects water height was 5 cm the tube

D. Data Communication Module of ESP8266.

We used the ESP8266 WiFi Module as a Data communication. This module will send the results of nutrition monitoring via thingspeak.com and the Android Smartphone application. If the monitoring results show a nutrient pH of less than 5.5, the system will control by spraying a particular solution to increase the pH value of the nutrient. If the result of monitoring the nutrient pH is greater than 6.5, the system will spray water to reduce the pH value of the nutrient. Thus the pH value of nutrients is controlled in the range value of 5.5 up to 6.5.

The ESP8266 as a communication protocol WiFi module circuit is described in Fig. 9. This module will be connected to an internet signal, where ESP8266 will send monitoring data from Arduino Uno to thingspeak.com.

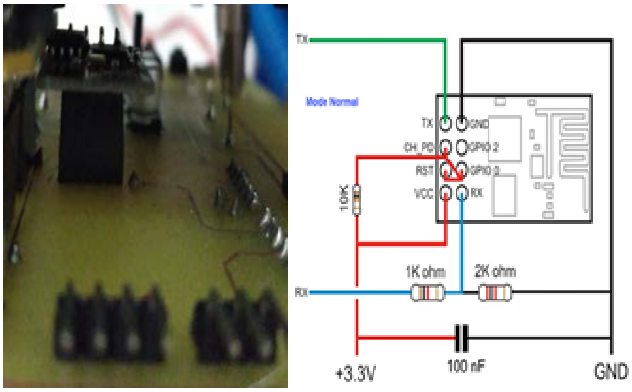

Fig. 9. Data Communication Module of ESP8266.

E. Temperature Humidity

Humidity sensor is special devices consisting of characteristic semiconductor materials that change according to the amount of air humidity. Basically this sensor is based on the number of water vapor. In this research, we use the HSM-20G sensor because the sensor can be converted to DC voltage which can be run with a digital system. Conversion between sensor output vs. humidity is described in Table IV.

TABLE IV
SENSOR OUTPUT VS HUMIDITY

output (Volt)	0.74	0.95	1.31	1.68	2.02	2.37	2.69	2.99	3.19
% RH	10	20	30	40	50	60	70	80	90

Temperature and humidity software application is described in Fig. 10.

Fig. 10. The IoT software application in Android.

V. CONCLUSION

This paper presented monitoring and controlling the nutrition, water level, and humidity of agriculture plant system. We describe that this nutritional control device has the potential to improve the quality of hydroponic plants. This system integration can support the Internet of Things. Therefore, the user can access at any time in any place. The system provides options of application, so the users can flexible to select of IoT devices or changed the agriculture plant needed. This feature can be achieved because the application is an open platform that provides an application programming interface (API) to accommodate various types of control boards connected to sensors. The system allows the sharing of IoT devices among applications.

Based on the description and results of the study, it was found that the results of a pH sensor (automatic) were not much different from the calculation of the pH meter (manual). The average error is 0.232 or around 6.52%. The voltage released by the sensor varies according to the acidity the hydroponic nutrient. A sensor takes 1 second to calculate the pH value of hydroponic nutrients. As well as pH nutrition sensors will control the pH value of nutrients in the range of 5.5 - 6.5. If it is greater than 6.5, then the pH will be lowered by the system and if it is smaller than 5.5, then the pH value of the nutrient will be raised automatically.

The combination of the sensor and the micro-controller was successfully made to control not only the pH of the nutrient, but also the high nutrient, humidity, and temperature hydroponic based on the Internet of Things.All observations and experimental tests prove that this project is a complete solution to field activities and nutrition problems. For future developments, it can be enhanced by developing this system for a large area of land.

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