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Original Article

An Intelligent IoT Based Hydrophonics for Smart Soilless Agriculture

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Abstract: *Agriculture is the backbone of human existence because it provides the bulk of the world's food supplies and a variety of other raw materials. It's a major factor in the growth and prosperity of any country. It also provides them with several commercial opportunities. Improvements to the national economy depend critically on progress in the agricultural sector. Planting is made more difficult in an uncontrolled environment by global warming. Farmers that practice sustainable agriculture rely on soil that is high in organic matter and naturally rich in minerals. It also needs a lot of space and water, and there are associated labor costs for plowing and weeding. When it comes to seasonal plants, the harvest falls short of both consumer demands and producers' hopes for increased output. As a result, farmers should seek out a technique that allows them to easily regulate environmental variables like temperature, humidity, and light intensity throughout the year while spending as little as possible. Hydroponic farming, in which plants are grown in a nutrient-rich solution rather than in soil and direct sunlight, is presented in this suggested study. In hydroponics, the roots of the plants are kept above ground and fed a solution of minerals and water. This technique is a form of indoor agriculture that is not affected by the weather and saves money by not necessitating plowing or other labor-intensive practices. Humidity, temperature, and water level are monitored and adjusted using a microcontroller Kit coupled to a wireless sensor network with internet. This Internet of Things technology would allow the authorized individual to check in on the plant's progress in real time, wherever they might be. In addition, LSTM, a deep learning model, is employed to anticipate potential outcomes.*

Keywords: *IoT, Hydrophonics, Soilless Agriculture.*

I. INTRODUCTION

Hydroponics, by definition, is the practice of growing plants without soil. Growing plants without soil is possible with this subset of hydroculture.This method allows roots to take advantage of the water's nutrient content and meet their full growth potential. It's also possible to use this technique to cultivate plants in liquid, sand, or gravel by just adding fertilizers.Hydroponics has been used in commercial agriculture and gardening in recent years. Residents of dense urban areas are also employing this technique to cultivate their own supply of locally grown produce.

There are two primary categories of hydro systems that make use of a solid medium: container systems and slab systems. In hydroponics, the plant-holding medium can be made from a variety of inert materials as rockwool, coir, sand, perlite, sawdust, wood chips, and so on.Factors like as crop, growing environment, geography, and season have a significant impact on the fertilization needs of hydro systems. The crop will only thrive if the fertilizer solution is ideal for all four of these conditions. Hydroponics growers just getting started are advised to follow the manufacturer-recommended comprehensive fertilization regimen.

II. LITERATURE SURVEY

A smart, low-cost IoT-based control and monitoring system for hydroponics greenhouses was designed and implemented by K. Tatas et al. The greenhouse keepers can check on these metrics remotely by logging through a website. The system's minimal energy needs make it ideal for use in remote areas without access to the power grid.J. Li et al. investigated the environmental regulation system for hydroponics. The system adjusts its routine maintenance schedule based on forecasts of the future growing conditions and observations of human habits.C. J. G. Aliac et al.'s goal is to create a system in which plants can flourish, one in which the pH, water level, ambient temperature, and relative humidity can all be precisely controlled. This technology also allows for the mechanized regulation of water irrigation and the consumption of nutritional solutions. Peuchpanngarm et al. created a do-it-yourself hydroponics smartphone app for autonomous control using sensors. Hydroponics planning for the following grow will be informed by the harvest data. In addition, people may check in on their plants from afar.In this study, the authors report on the development of an automated system that uses sensors and a micro-controller to streamline the entire procedure. Here, an Android app is used to keep tabs on the settings of an Internet of Things-based hydroponics system. Information collected from a variety of hydroponic farms will be used to refine the technology.Hydroponic plant growth can be automated with the help of fuzzy logic control, as demonstrated by M.

Fuangthong et al. The outcomes demonstrate that EC and pH value can be effectively adjusted using a system based on fuzzy logic control to aid plant growth. The technique also helps lessen resource wastage.

Hydroponic plants for aquatic induction were presented by Chaotao Liu and colleagues. Hydroponics cultivation fuzzy control system also developed. The system's ability to grow hydroponically without human oversight has been demonstrated by its successful operation.Phutthisathian et al. demonstrated the Protégé-based ontology for controlling nutrient solutions in hydroponics. To aid in making the right choices with the hydroponic nutrient solution control system, we take into account the characteristics of electrical conductivity (EC), Potential of Hydrogen ion (pH), intensity of solution, species of plants, and the relationship of the device in the system.Kaewwiset et al. programmed an automatic controller to calculate the EC and pH adjusting equation and fill the reservoir with the appropriate amount of A&B solution or nitric acid to maintain the desired EC and pH. Takeuchi et al. proposed a process for digitally fabricating hydroponic systems, which allow for the soil-less cultivation of a wide variety of plant species. Finally, the paper will examine potential future directions for expanding the pipeline to enable the manufacture of more sophisticated ecological systems.Baek et al. introduced a technique that allows for non-destructive plant tissue assessment with minimal heat exposure. We show that it is possible to detect sap flow regularly in a greenhouse tomato tree over the course of a month, which could have production-scale implications.Joshitha et al. incorporated an IoT into our solution and used Solar Energy to cut down on power usage. When applied to hydroponics, IoT enables farmers to monitor plant development by providing data on environmental factors like water and humidity levels. Cloud-based sensors collect the relevant data to compile the statistics.

III. PROPOSED SYSTEM

We have implemented an Internet of Things (IoT) enabled smart hydroponic system in this project. Hydroponically grown plants were subjected to a range of treatments before their morphological characteristics were analyzed.

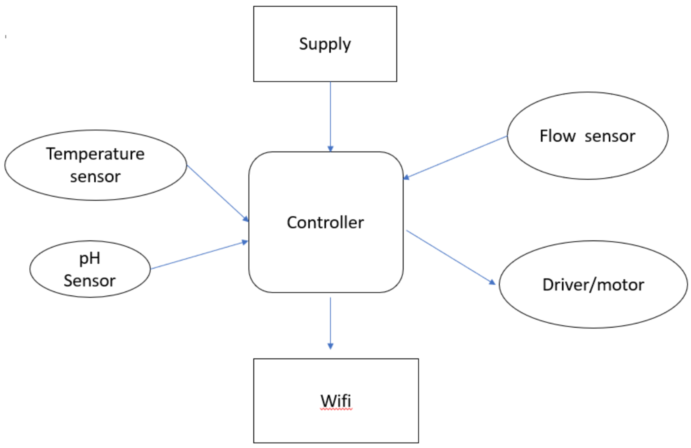


Figure1: Proposed System Block Diagram

A. Components Used:

- Arduino controller
- Flow sensor
- Temperature sensor
- pH sensor
- Flow Sensor
- The hall-effect sensor, water rotor, and plastic valve body make up the water flow sensor. The rotor spins because of the water pressure. The rate at which it moves is variable. The equivalent pulse signal is produced by the hall-effect sensor.
- Potential transformer
- Potential transformer is a voltage step-down transformer which reduces the voltage of a high voltage circuit to a lower level for the purpose of measurement.
- These are connected across or parallel to the line which is to be monitored.

B. LSTM Based Prediction

Keras and TensorFlow both have support for the LSTM model. This work's proposed model is primarily used to offer a classical comparison of time series forecasting, and it works as expected: it can perform efficient prediction within a constrained time interval, with the outcome depending on the length of the interval.

Modules

- Collecting Information
- Pre-Processing
- Training
- Forecasting and Assessing

C. Data set collection

Information gathered by an Arduino board. The full data set of flow rate, pH, and temperature is included here.

D. Pre-Processing

At initially, information is gathered from an Internet of Things server. The information could be in a variety of formats, including structured, semi-structured, or unstructured data. Normalization is performed during the pre-processing phase of Training.

E. The Attention-LSTM Model under Construction

a)LSTM Model:

In this short introduction, we will cover the basics of the LSTM model. Figure 1 illustrates that LSTMs.

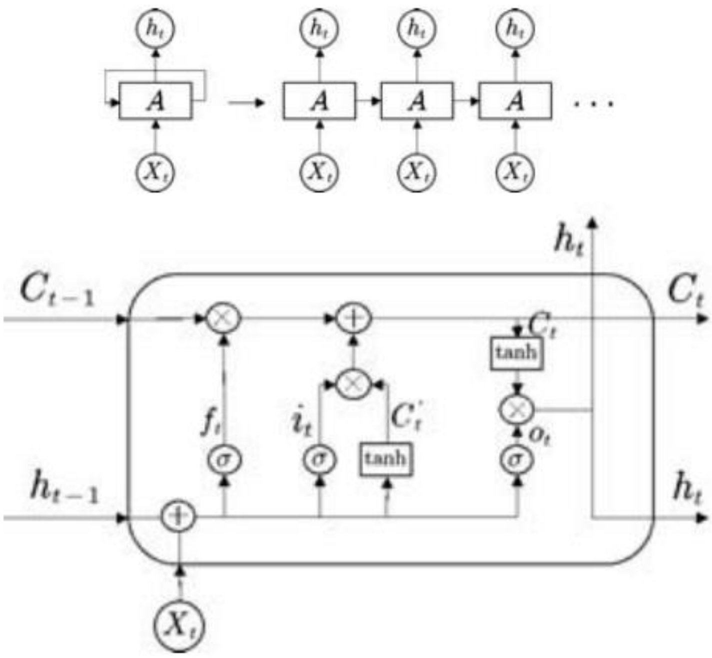


Figure 2: The Structure of LSTM Cell

This unit consists of the "forgotten gate," the "input gate," and the "output gate." The Sigmoid function (denoted by) provides a value between 0 and 1 that characterizes the pass through ratio of each component.

$$f_t = \sigma\left(W_f \cdot [h_{t-1}, x_t] + b_f\right)$$

$$i_t = \sigma\left(W_i \cdot [h_{t-1}, x_t] + b_i\right)$$

$$\tilde{C}_t = \tanh\left(W_c \cdot [h_{t-1}, x_t] + b_c\right)$$

$$C_t = f_t \cdot C_{t-1} + i_t \cdot \tilde{C}_{t'}$$

$$o_t = \sigma\left(W_o\,[h_{t-1}, x_t] + b_o\right)$$

$$h_t = o_t \cdot \tan\mathrm{h}\left(C_t\right)$$

ft is one of them, and it controls the amount of data we throw out. It tells us how much fresh data to incorporate. ot controls the level of detail we choose to convey. Time-input variable xtThe output of the previous gate is denoted by t. ht1, the weight is denoted by Wf, Wi, Wc, and Wo, and the bias is denoted by bf, bi, bc, and bo. The prior cell state, denoted by Ct1, and the current cell state, denoted by Ct, are shown below.

b) Attention-LSTM Model:

Information from a long time ago may be crucial to the current value, but the model has a hard time learning it. We attempted to strengthen the LSTM network by adding an attention layer to address the shortcoming. The LSTM model can benefit from the attention implementation described in [9]. Figure 3 illustrates the extension of the LSTM model with an attention layer.

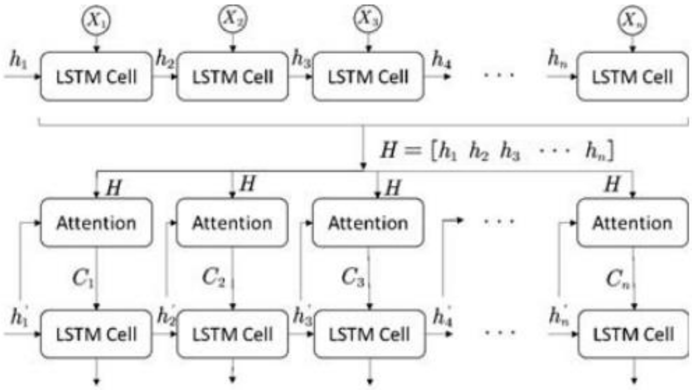


Figure 3: The Process of Adding an Attention Mechanism to the LSTM Model

The intermediate output result of each cell is passed to the attention model as H for an input of Xi, i (1, n), and the elements of the next layer hi are also passed to the attention model as H for the computation of the similarity and weight coefficients. The following diagram depicts the first iteration of the attention model.

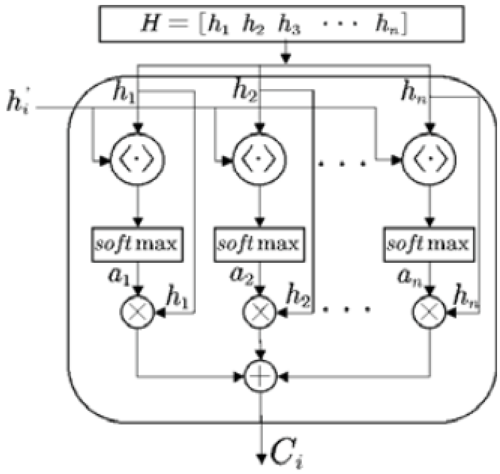


Figure 4: The Internal Structure of Attention Model

Where,indicates the dot product operation used to compute the similarity between the current element and the intermediate output result of the preceding layer; this similarity is then normalized by the softmax function to get the associated weight coefficient ai. The Attention value Ci is then calculated by a weighted summation procedure. The attention layer's formula is as follows:

$$H = [h_1 \ h_2 \ \cdots \ h_n]$$

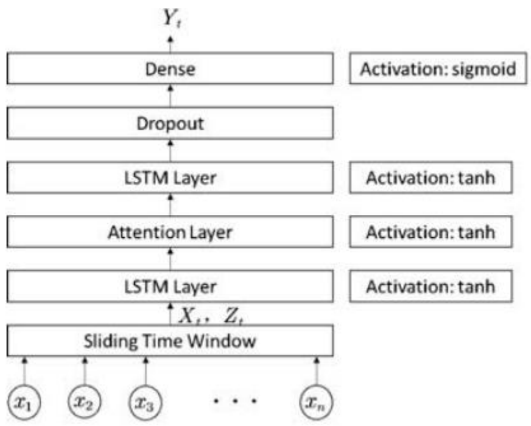
$$H_i^{'} = \left[h_i^{'} \ h_i^{'} \ \cdots \ h_i^{'}\right]$$

$$sim_i = H_i^{'} \cdot H^T$$

$$a_i = \frac{e^{sim_i}}{\sum_{j=1}^{L_h} e^{sim_j}}$$

$$C_i = \sum_{j=1}^{L_h} a_i \cdot h_j$$

The softmax function is used to normalize the weight in the previous equations, and the normalized weight is then used in the weighted sum of ai and hi. The summation's weighted result of attention is denoted by the attention weight value, Ci.To build the Attention layer, we first store the intermediate output results from the input sequence generated by the LSTM encoder, and then we calculate the weight factor based on the similarity between those intermediate results and the current output. The attention coefficient has been attained.



.

Figure 5: Schematic of the Attention-LSTM Network

Figure above shows how the original traffic flow data is transformed into a feature matrix and label vector by employing a sliding time window method. The final prediction Y is reached by correlating the values of matrix X with those of vector Z and retrieving the attention weights via the attention layer.

c) Proposed Algorithm 1:
Input: Sensor Data
Output: A trained Attention-LSTM model.

- Construct a dataset with a sliding time window,includingXt and Zt.
- Normalization Xt and Zt.
- Input features matrix Xt and current disease vector Zt to A-LSTM network.
- While training epoch does not reach the set value do
- Put (Xt, Zt) into the Attention-LSTM network for forward propagation.
- Calculate the attention weight corresponding to each element
- Generate Yt
- Calculate mean square error.
- Use RMSProp update weights for A-LSTM network.
- End while return A trained Attention-LSTM model.

For long time series and significant prediction lag time, the LSTM model's performance is validated based on the attention mechanism. There is uniformity in the construction and application of all prediction models. We use LSTM architecture with 2 hidden layers, 64 neurons per hidden layer, and a learning rate of 0.05. To optimize a network, RMSprop is used. Algorithm 1 depicts the training of an Attention-LSTM model.

F. pH Sensor:

Arduino-powered PH probe. Arduino pH sensor investigates composition from the inside ThepH probe has a neutral solution of potassium chloride within and a hydrated gel coating on the exterior. Put two in use with the Arduino. To rephrase, the molar concentration of hydrogen ions equals 10 to the power of the negative pH value, where pH is the negative log of that number.

When designing an aquatic environment, be it an aquarium, hydroponic system, or fully automated aquaponic system, a pH meter can be an invaluable tool. Figure 1 depicts the arduinoph meter's circuit. I'll be testing this extremely basic program on a small set of liquids whose known pH values will serve as examples.

G. Arduino:

Arduino is a user community, open-source hardware and software project, and manufacturer of microcontroller-based kits for creating devices that can sense and control items in the real world.

A number of different suppliers' microcontroller board designs are being used in this project. Digital and analog I/O pins are provided on these systems so that they can be connected to a wide variety of add-on circuits and boards (called "shields").

H. Flow Sensor:

Figure 6: Flow Sensor

The velocity, volume, and direction of a fluid in motion can all be measured. There are many different techniques to quantify flow. Here is a list of the most frequently used flowmeters in factories: Differential-pressure or variable-area obstructions are two examples of a) a) Turbine-based inference c)electromagnetic d)Positive-displacement flow meters collect a constant volume of fluid and use the counting of fills to determine the rate of flow. Fluid dynamics (vortex shedding), f) Anemometer, g) Ultrasonic Coriolis mass flow meter.

I. DC Motor:

Any rotary electrical motor that uses a direct current electrical supply to generate mechanical energy is referred to as a DC motor. Magnetic field forces are used by the most popular forms. Almost all DC motors need an electromechanical or electrical system to periodically reverse current flow within the motor.

Figure 7: DC Motor

J. ESP32 Development Board:

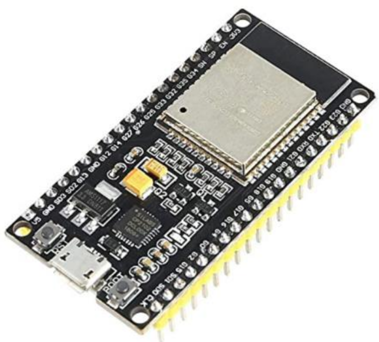


Figure 8: Bluetooth Module

Because of its built-in TCP/IP protocol stack, any microcontroller can connect to your WiFi network with the ESP-01 ESP8266 Serial WIFI Wireless Transceiver Module. The ESP8266 can act as a standalone application host or it can delegate its Wi-Fi networking tasks to another processor. With the AT command set firmware already loaded on each ESP8266 module, you can immediately begin using your Arduino with the same degree of WiFi capability as a WiFi Shield. The ESP8266 module is a low-cost board with a sizable and expanding user base.

IV. IMPLEMENTATION RESULTS

hydroponics_project | Arduino 1.8.16

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hydroponics_project

```
#include <OneWire.h>
#include <DallasTemperature.h>

// Data wire is plugged into digital pin 2 on the Arduino
#define ONE_WIRE_BUS A1

// Setup a oneWire instance to communicate with any OneWire device
OneWire oneWire(ONE_WIRE_BUS);

// Pass oneWire reference to DallasTemperature library
DallasTemperature sensors(&oneWire);

volatile int flow_frequency; // Measures flow sensor pulses
// Calculated litres/hour
 float vol = 0.0,l_minute;
unsigned char flowsensor = 2; // Sensor Input
unsigned long currentTime;
unsigned long cloopTime;
#include <LiquidCrystal.h>
LiquidCrystal lcd(13, 12, 11, 10, 9, 8);
void flow () // Interrupt function
{
   flow_frequency++;
}
void setup()
{
  sensors.begin();  // Start up the library
   pinMode(flowsensor, INPUT);
   digitalWrite(flowsensor, HIGH); // Optional Internal Pull-Up
   Serial.begin(9600);
   lcd.begin(16, 2);
   attachInterrupt(digitalPinToInterrupt(flowsensor), flow, RISING); // Setup Interrupt
```

Figure 9: Arduino Programming for Proposed System

hydroponics_project | Arduino 1.8.16

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```
 Serial.println(i);

  currentTime = millis();
  // Every second, calculate and print litres/hour
  if(currentTime >= (cloopTime + 1000))
  {
   cloopTime = currentTime; // Updates cloopTime
   if(flow_frequency != 0){
     // Pulse frequency (Hz) = 7.5Q, Q is flow rate in L/min.
     l_minute = (flow_frequency / 7.5); // (Pulse frequency x 60 min) / 7.5Q = flowrate in L/hour
     lcd.clear();
     lcd.setCursor(0,0);
     lcd.print("Rate: ");
     lcd.print(l_minute);
     lcd.print(" L/M");
     flow_frequency = 0; // Reset Counter
     Serial.print("flow rate:");
     Serial.println(l_minute);

   }
   else {
     Serial.println(" flow rate = 0 ");
     lcd.clear();
     lcd.setCursor(0,0);
     lcd.print("Rate: ");
     lcd.print( flow_frequency );
     lcd.print(" L/M");


   }
  }
```

Figure10: Arduino Programming for Flow Measurement

V. CONCLUSION

Therefore, the suggested hydroponic system incorporates the growing of multiple crop types simultaneously. The system's flaws, such as its inability to cultivate more than one sort of crop, have been fixed. To control the system's operation, a methodical strategy has been developed. When comparing plants produced using this method to those cultivated in the conventional manner, it is discovered that the former develop more rapidly with less input. They use only the amount of water that is necessary, thus there is no waste of precious resources.When weighed against its benefits, cropping's price tag is also rather small. Therefore, this model promotes a different method of farming that is more sustainable and productive than emerging practices.

VI. REFERENCES

[1] C. Joshitha, P. Kanakaraja, K. S. Kumar, P. Akanksha and G. Satish, "An eye on hydroponics: The IoT initiative," 2021 7th International Conference on Electrical Energy Systems (ICEES), 2021, pp. 553-557, doi: 10.1109/ICEES51510.2021.9383694.

[2] R. Vidhya and K. Valarmathi, "Survey on Automatic Monitoring of Hydroponics Farms Using IoT," 2018 3rd International Conference on Communication and Electronics Systems (ICCES), 2018, pp. 125-128, doi: 10.1109/CESYS.2018.8724103.

[3] H. K. Srinidhi, H. S. Shreenidhi and G. S. Vishnu, "Smart Hydroponics system integrating with IoT and Machine learning algorithm," 2020 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT), 2020, pp. 261-264, doi: 10.1109/RTEICT49044.2020.9315549.

[4] S. Baek, E. Jeon, K. S. Park, K. Yeo and J. Lee, "Monitoring of Water Transportation in Plant Stem With Microneedle Sap Flow Sensor," in Journal of Microelectromechanical Systems, vol. 27, no. 3, pp. 440-447, June 2018, doi: 10.1109/JMEMS.2018.2823380.

[5] Y. Wei, W. Li, D. An, D. Li, Y. Jiao and Q. Wei, "Equipment and Intelligent Control System in Aquaponics: A Review," in IEEE Access, vol. 7, pp. 169306-169326, 2019, doi: 10.1109/ACCESS.2019.2953491.

[6] Y. Takeuchi, "3D Printable Hydroponics: A Digital Fabrication Pipeline for Soilless Plant Cultivation," in IEEE Access, vol. 7, pp. 35863-35873, 2019, doi: 10.1109/ACCESS.2019.2905233.

[7] T. Kaewwiset and T. Yooyativong, "Electrical conductivity and pH adjusting system for hydroponics by using linear regression," 2017 14th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2017, pp. 761-764, doi: 10.1109/ECTICon.2017.8096350.

[8] D. Saraswathi, P. Manibharathy, R. Gokulnath, E. Sureshkumar and K. Karthikeyan, "Automation of Hydroponics Green House Farming using IOT," 2018 IEEE International Conference on System, Computation, Automation and Networking (ICSCA), 2018, pp. 1-4, doi: 10.1109/ICSCAN.2018.8541251.

[9] A.Phutthisathian, N. Pantasen and N. Maneerat, "Ontology-Based Nutrient Solution Control System for Hydroponics," 2011 First International Conference on Instrumentation, Measurement, Computer, Communication and Control, 2011, pp. 258-261, doi: 10.1109/IMCCC.2011.260.

[10] Chaotao Liu, Zushu Li and XiaohuiZeng, "Fuzzy control system for hydroponics cultivating," 2008 7th World Congress on Intelligent Control and Automation, 2008, pp. 7804-7808, doi: 10.1109/WCICA.2008.4594146.

[11] M. Fuangthong and P. Pramokchon, "Automatic control of electrical conductivity and PH using fuzzy logic for hydroponics system," 2018 International Conference on Digital Arts, Media and Technology (ICDAMT), 2018, pp. 65-70, doi: 10.1109/ICDAMT.2018.8376497.

[12] N. K. Bharti, M. D. Dongargaonkar, I. B. Kudkar, S. Das and M. Kenia, "Hydroponics System for Soilless Farming Integrated with Android Application by Internet of Things and MQTT Broker," 2019 IEEE Pune Section International Conference (PuneCon), 2019, pp. 1-5, doi: 10.1109/PuneCon46936.2019.9105847.

[13] C. Peuchpanngarm, P. Srinitiworawong, W. Samerjai and T. Sunetnanta, "DIY sensor-based automatic control mobile application for hydroponics," 2016 Fifth ICT International Student Project Conference (ICT-ISPC), 2016, pp. 57-60, doi: 10.1109/ICT-ISPC.2016.7519235.

[14] C. J. G. Aliac and E. Maravillas, "IOT Hydroponics Management System," 2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology,Communication and Control, Environment and Management (HNICEM), 2018, pp. 1-5, doi: 10.1109/HNICEM.2018.8666372.

[15] J. Li, Z. Mao, Z. Cao, K. Tei and S. Honiden, "Self-adaptive Hydroponics Care System for Human-hydroponics Coexistence," 2021 IEEE 3rd Global Conference on Life Sciences and Technologies (LifeTech), 2021, pp. 204-206, doi: 10.1109/LifeTech52111.2021.9391909.

[16] K. Tatas, A. Al-Zoubi, A. Antoniou and D. Zolotareva, "iPONICS: IoT Monitoring and Control for Hydroponics," 2021 10th International Conference on Modern Circuits and Systems Technologies (MOCAST), 2021, pp. 1-5, doi: 10.1109/MOCAST52088.2021.9493387.