Automated Hydroponics Systems, A Review and Improvement

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Abstract: ***Harmful chemicals in weedicides, pesticides, and artificial coloring which are used in commercial crops are an issue for many consumers and buyers, everyone desires and deserves healthy food. This will create a need or demand for healthy crops without pesticides. One solution for this problem is Hydroponics in which plants are grown without soil while nutrients are supplied through water, however, due to the busy nature of people and more and more people moving away from agriculture, researchers came up with an automatic way to grow hydroponic plants. The nutrient-rich solution is pumped with the help of a motor while sensors manage temperature, electrical conductivity, humidity, and light with the help of a microcontroller. Grow lights are installed to grow plants in an indoor environment. In this paper, we are going to discuss the previous works in the fields of automation of hydroponics and propose our architecture for an automated hydroponic system.***

Keywords: Hydroponics, IoT, Automation.

1. Introduction

The ever-increasing human population along with shrinking spaces and demand for disease-free, without weedicides, pesticides, and other harmful chemicals has created a need for a technique that requires less space and grows crops without soil without the use of harmful chemicals.**[1]**

Hydroponics is the method of growing crops without soil, it allows efficient use of water, energy, space, and cost of the plant. It is extremely suitable for growing green leafy plants like spinach, lettuce, and broccoli. It not only grows healthy plants without pests, weeds and worms but it also grows them in much less time compared to traditional farming. There are six types of hydroponic systems namely Wick Hydroponic, Deep-water culture Hydroponic, Drip hydroponic, EBB and Flow hydroponics, Fogponics, and Nutrient film technique. Plants require 16 elements to growth namely Carbon(C), Hydrogen(H), oxygen(O), calcium (Ca), phosphorus (PH), potassium(K), nitrogen(N), sulfur(S), magnesium (Mg), boron(B), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), molybdenum (Mo) **[2].** The proportion of all these nutrients is essential for the growth of a plant. Excessive amounts can be troublesome and damage the crop. In a hydroponics system, everything is supplied except H, C, and O which will be taken by the plant itself from air and water **[2].**

In this review article, we will discuss the Automated hydroponics system with the help of IoT (internet of things) and propose our design of an Automated Hydroponic system, in a typical AHP system parameter that controls the growth of plants such as humidity, temperature, electrical conductivity, lights are all managed by sensors which are connected to a microcontroller. For supplying nutrients an auto-doser is created which mixes the nutrients and supplies it with water with the proportion. Grow lights are used where the growing environment is indoor, and the climate is not suitable such as in poles or countries far away from the equator. Some systems may even have a camera module to detect and identify diseases and alter the user. A website or an android application is created to update users about the information of the system.

2. Literature Survey

In **[3]** the authors have used a Deep-Water Culture system to grow a mustard green plant, the authors have used an ArduinoMega 2560 microcontroller and used; C++ language to program it. The authors used an Atlas sensor to measure the pH level in the water solution and signal it to the actuator, if the pH drops, it is automatically adjusted. If the pH is not in the range of 6.00-7.50 the microcontroller will signal for motor up or down for pH increase or decrease respectively. This system used two tanks, which were the main tank and the hydroponics tank. The position of the hydroponics tank was placed above the main tank so that the water solution in the hydroponics tank could be easier to transfer back into the main tank for the rechecking of the pH level in the water solution after a certain period. The water solution into the main tank was done by the solenoid valve. The use of Arduino to manage the system saved the cost and energy of the system. A motor stirrer was used to normalize the pH of the water solution. However, the use of the Atlas sensor instead of the pH-0091 sensor makes the system more inaccurate as the Atlas sensor has an error rate of +0.59 to -0.59 compared to pH-0091.The system also lacks the modules for temperature and humidity.

In **[4]** the authors have taken parameters such as pH, EC, water level, light intensity, temperature, and humidity to be monitored and controlled. The authors have used a microcomputer (Raspberry Pi), and an Arduino microcontroller to manage sensors and retrieve data. The system can control humidity and PH with the help of a humidifier and doser. The authors have used Kerro make pH sensor, Keystudio make TDS sensor, and HRC-SR04 distance measuring sensor. Temperature is controlled by a cooling fan; humidity is controlled by a fogger and water circulation is done by a circulation pump. The Arduino microcontroller is used to manage and take data from the sensor which in turn is sent to Raspberry Pi through serial communication. A Decision Tree algorithm was deployed in

Raspberry Pi to process the data taken by the sensors and decide the output actions based on data given by the sensor. The system uses a cloud platform named (ThingSpeak) which collects and visualizes the data posted by devices to a server for monitoring of the users. The data through sensors and actuators are updated to ThingSpeak. ThingSpeak provides instantaneous visualizations of data posted by the devices to the server. The mobile application is developed on the Android platform mainly to monitor the hydroponic parameters and the status of the actuators. The user interface enables the user to view the values of the hydroponic farm parameters through a mobile application. The user interface is designed by MIT app inventor which is an online platform to develop mobile applications.However, their system cannot grow crops in indoor or dark environments due to a lack of grow light, furthermore, they also lack a system to continuously monitor their system for diseases and insects.

In **[5]** the authors have created an Automated Hydroponics system using ARM Cortex-M4 processor-based microcontroller running an open source embed Realtime OS where MIT MediaLab launch OpenAg tool was used. Here the parameters used are the levels of pH and nutrients on the nutrient content of hydroponics, the system can read the temperature, humidity, CO2 levels, and light intensity around the system. The authors also have implemented light sensors to sense the light intensity which is necessary for the growth of plants. The authors have used a DHT22 and MH Z19 sensor to measure the humidity and CO2 levels of the system. DHT22 Humidity sensor experiment was taken for 600 seconds with data were taken every 30 seconds in physics rooms; results were compared with the measuring instrument. MH-Z19 sensor experiments were taken for 25 minutes with data taken every 1 minute in rooms, results were compared with measuring instruments, Authors also used an LCD module to update about the ongoing process like mixing or timer flush. The system provides 5ml nutrients initially, and then the amount is substantially increased by calculating. Data collection was done using Quantum PAR Meter measuring instrument at a 30 cm distance from LED to plant hole. The LED Coefficient was obtained by dividing Average Light Intensity by Lux. The system is good when keeping a track record of all the threads happening behind the screen which is displayed with an LCD. However, the system does not have a real-time visual monitoring system. The authors have also not created a mobile or web application for displaying results to the user.

In the system created by **[6],** the authors have created an NFT hydroponics system which is controlled by a microcomputer (Raspberry Pi 3), like most authors they have taken parameters like temperature, and humidity, pH, Light intensity which are essential for the growth of a plant. The authors have also implemented a module to control the intensity of the module and they have five pumps to control the contents of the solution they also have implemented an air pump as well as a water pump to increase the concentration of oxygen in the solution. Their system has the advantage of giving plants oxygen to prevent the death of crops as well the intensity of the lights of the system is also calculated. However, the system is not implemented in a website or an android application to make the user aware of the system when the user is not near it, like the previous two it also lacks visual real-time monitoring.

As presented in **[7]** the authors created an NFT system and automated that using a Raspberry Pi microcomputer, unlike previous authors who used Arduinos, the authors here have used a PIC18f4525 microcontroller which can convert analog to digital signals to convert data from PH and temperature sensors. The authors have used LM35 temperature sensors which are connected to a PIC18f4525 microcontroller which also manages AC and DC motors to control the flow of solution in the NFT system. The microcomputer Raspberry Pi is attached to an ultrasonic sensor SRF08 to measure the water level. Raspberry Pi can control AC/DC motors through Inter integrated circuit. Along with all this, the authors have also used a SEN016 sensor to measure the pH of water flowing through the NFT system. The authors have used C language to program the microcontroller and MPLAB ICD 2 to code, edit and debug the program. MPLAB is property freeware integrated environment software to program embedded systems in PIC. The authors used ZN (Zeigler Nicolas) method to determine PH coefficients *Kp, Ti,* and *Td*. For the users, the authors had created a web interface that updates them with temperature, pH value, water level, and PWM. This system has a pro that is the PID controller is used to regulate three parameters-proportional gain, integral time, and derivative time, if the pH is not between 5.5 to 6.5 the PID will normalize it to that level. The use of LM35 is much better than DTH11 which is much more accurate and has a higher range and requires less current than DHT11 while calculating temperature. However, using LM35 rises the cost of the system as it is much costlier. The system also lacks a humidity sensor to calculate humidity as it is an important factor for the growth of plants. The system also lacks a disease detection module and a visual real-time monitoring system.

In **[8]** the authors have used two Arduinos as nodes to collect data from sensors and a third Arduino to act as anIoT gateway. The third Arduino supplies data to the Raspberry Pi and then the Raspberry Pi runs a local server to host the web interface and mobile application. The authors have used four sensors (pH, water temperature, humidity, Electrical conductivity) along with a LED Grow light, managed by Arduinos. The pH probe is used to calibrate the pH using calibrating liquids. The authors have also installed a fan to cool down the system. A web interface named Domoticz is hosted through Raspberry Pi, Domoticz is used to visualize the data given by the system, along with giving information collected by the sensors like humidity, and electrical conductivity can also allow the user to toggle the light on/off. A clock is used to keep track of real-time. The fans and lights are controlled through a relay module. A camera is used to capture images and send them to the user through the Domoticz web interface. Domoticz can also be used via a mobile application. The system despite being costly is a complete product with lots of features like image capturing and LED grow lights which can be toggled by the user. However, the system is much costlier than previous ones due to the addition of three Arduino and a Raspberry Pi. It could have been made cheaper as it is a full-end product, as well as the product, lacks the use of Deep learning to monitor the crops.

In **[9]** the authors have divided the system into three states client-side, server-side and graphical user interface, in the client-side the microprogrammed to manage the system with sensors and actuators. Humidity and temperature of the room, temperature level when the water is mixed with the solution, and the horticultural lighting to provide the right illumination for the plant at night. On the server side, the MQTT broker server is set to transfer the data from the microcontroller to any platform that can read MQTT data. To properly implement the MQTT broker server, hosting a Raspberry Pi microcomputer has been used. Raspberry Pi 3 has been used as the host for the server at port 1883 to access the mosquito MQTT broker server authentication (username and password). It ensures that only specific devices are connected to the server. To provide services to IoT, a free IOT server NodeRed has been used. It is a visual tool to wire the internet of things. The last is a graphical user interface that was deployed by NodeRed itself to display in a web form that can be hosted in the cloud. Also, a mobile application was developed that displays GUI in IOS. There is an optional module for writing the whole GUI with HTML, CSS, and JavaScript which will be hosted by private browsing. Like previous authors, they have taken four parameters such as temperature, humidity, electrical conductivity, and pH which are the most important parameters for the growth of the plant. A Printed Circuit board was designed and created using design spark software. Moreover, an ultrasonic sensor was also deployed with NodeMcu Esp8266. For alerting the user, the authors have also used the APIs of telegram and Nexo. Using this system can alert the user by custom notifications. The system is quite complicated compared to previous authors however it is a large-scale high-end product, the authors have focused a lot on User interface and user experience compared to previous authors. The system is good and accurate since the authors have personally designed their printed circuit board instead of commercially available hardware. One of the major setbacks is the lack of real-time monitoring like other authors; however, authors have mentioned this in their future scope.

The system created by the authors in **[10]** uses an Arduino with sensors to manage parameters like pH, Temperature, and Humidity, an ultrasound module was used to detect the level of water flowing in the system. LED grow lights were also embedded to grow crops. The authors have used Message queuing telemetry transport (MQTT) a lightweight public subscribe network protocol that transfers messages between devices to transport messages between publisher and subscriber by establishing a TCP connection with a server named broker. The authors have used Firebase, cloud storage, and API to support web applications and IOS/Android applications. Based on the author's experimental findings, vegetables grown in orange LED (20000-40000) were better than vegetables grown than the regular approach. The authors have also created multiple user satisfaction Blackbox tests to confirm whether their system is satisfying all user requirements or not. Their study has revealed an important finding that orange light is better suited than other lights to grow crops also they have taken great care about the system user experience. They have also managed to control the system with only one microcontroller. Their system is as good as it gets however like most authors here the system lacks a real-time monitoring module or a disease detecting image processing module.

In **[11]** the authors, unlike previous works, have created an image processing module in their NFT hydroponic system with the help of a camera that captures the image and uploads it to a cloud database. The system has a solenoid valve to maintain the pH of the system along with an oxygen pump that oxygenates the solution. Their visual system can not only detect infection in plants and alert the user but also notifies the user of the time to harvest using a mobile application. Along with disease detection, the system also gives details about the infection to the user. The system has the advantage of visual processing to real-time monitor the plants grown in the system, however, due to a lack of grow light and a proper nutrient doser this system cannot grow crops in an indoor environment and needs a manual force to mix the nutrients.

In **[12]** the authors have deployed a robot on a Hydroponic System based Nutrient Film technique. The robot is used to manipulate seedlings without human intervention. The authors have used a Microsoft Kinect and a Position-based visual feedback algorithm to detect plants by images and the position of the plant. The robot consists of the robot being driven on the x, y, and z-axis through a stepper motor (Applied Motion STM23S-3RN) and it also has three actuators for its gripper at the end of its arm. Two linear actuators are used to open and close the gripper and the third one is used to rotate the gripper around the y axis. All three linear actuators are driven by a 12V relay board that communicates with a Phidgets PhidgetInterfaceKit 1019. The robot has a camera system (Microsoft Kinect) to get the images of the NFT system in depth per pixel. The Kinect is a low-cost and readily available RGB-D camera. The Kinect is located on the carriage and is facing downwards (negative z-axis). The Kinect is positioned in such a way as to ensure the plants in its field of view are at a maximum distance of 1.5 m because the accuracy of the Kinect decreases quadratically with distance. Up The computer vision algorithm was implemented using C++ programming language using OpenCV library. The gullies which are located on the x-axis are detected using probabilistic Hough transform for line detection. Since all plants are located in circles the plants which are not in segmented gullies are deleted. To be able to pick up the plant coordinated needs to be transformed into a gantry coordinate.

2.1. Other technologies used in automated hydroponics projects:

In **[13]** the authors have used five different PVC-based Ion-selective membranes to sense macronutrients in a different mixture of chemicals for sensing nitrate, potassium, calcium, and magnesium ions. Ion-selective membranes are used to convert the number of Ions in a solution into electrical conductivity. In the findings, TDDA (tetra-dodecyl ammonium nitrate)-NPOE (2-nitropHenyl octyl ether, KTpCIPB) and valinomycin the values of NO3 and K membranes were linearly proportional to the logarithmic values of NO3 and K concentrations.

In **[14]** the authors have used four stages: image acquisition of plant leaf, pre-processing of images, image segmentation, feature extraction, and classification of images of different disease classes. Image acquisition is done with the help of a mobile camera. The dataset contains 120 images of healthy, infected leaf images. In pre-processing stages are applied to a given image so that it made the image appropriate for the additional process. In segmentation, the background is subtracted using color-based subtraction or cluster-based subtraction. In the final classification, the features are extracted by feature extraction. The feature extraction technique permits the extraction of the properties of an image which will be able to facilitate accurate classification.

3. Suggestions and Improvement

In this paper we are suggesting an improvement to develop a Hydroponic system having an NFT structure, Here the system will work on flow water, The basic idea is that the flowing water will reduce the risk of algae/fungus settling inside the gullies/channels of the NFT system. During germination, no nutrient is required by the plant as the seed itself contains several amounts of nutrients to germinate from seed to seedling though some amount of nutrients can be provided within a certain limit.

After the germination period when the seedling is successfully grown and transplanted to the NFT system manually, the actual part of automation will take place. For the growth of plants several nutritional and environmental factors are required, nutritional factors such as the pH of the growing medium and Necessary nutrient requirements such as Nitrogen, Phosphorous, Potassium, etc. also we're going to use is the Reverse Osmosis (RO) water since it will contain very few amounts of total dissolved solvents which will reduce the chance of unknown minerals present in the water.

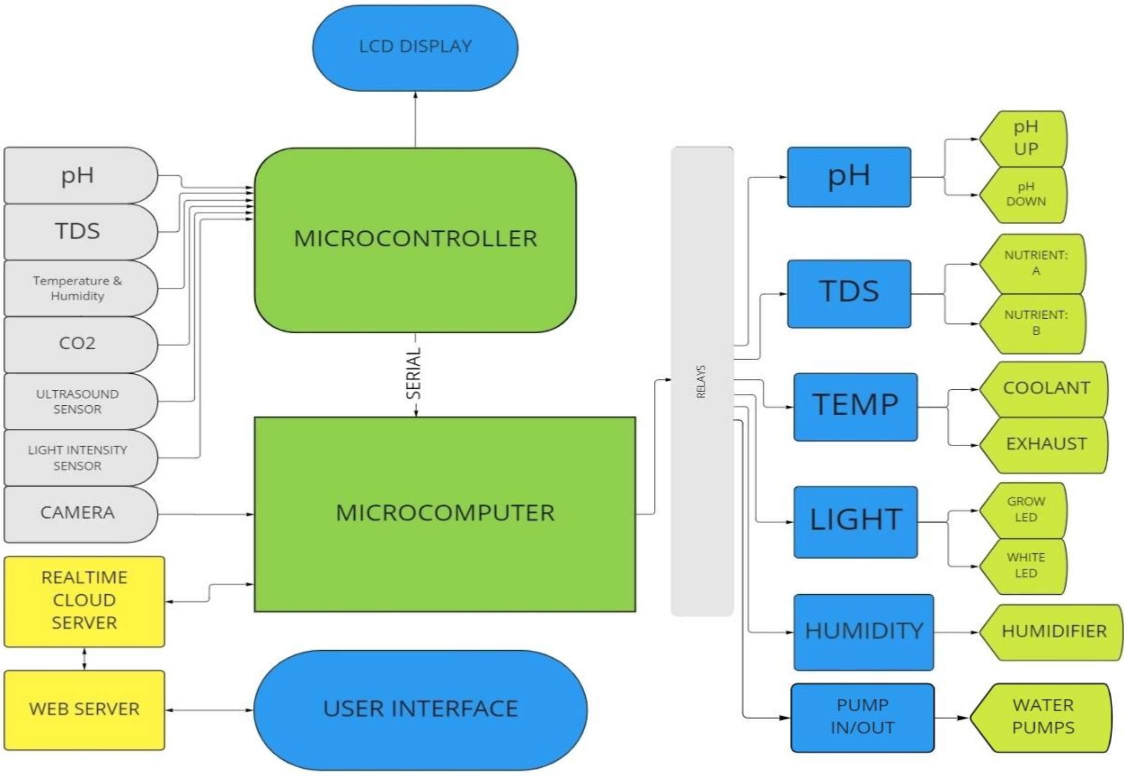

Figure 1: System Design of our Automated Hydroponics System

3.1 Sensors

In comparison with the proposed system of previous authors, we are going to suggest our improved methodology. In **[3]** the author has used sensors only to get obtain the pH of the liquid. Whereas in **[7]** the author has used a temperature sensor, ultrasonic sensor, and pH sensor. Improvement to that in **[8]** the author has used sensors for parameters pH, water temperature, temperature &humidity, TDS. In **[9]** the author has used sensors for parameters pH, TDS, Water Level, temperature and humidity, light intensity, similarly in **[5]** the author has used sensors for parameters such as pH, TDS, temperature, humidity, light intensity along with CO2. In **[6]** the author has presented the use of sensors for parameters pH, temperature, humidity, Light Intensity. Here in **[7],** the author has used sensors for parameters pH, Temperature, and Water Level only. Here in **[9],** the author has used sensors only for parameters pH, Humidity, and water level. In **[10]** the author has used parameters sensors such as pH, Ultrasound, and Light intensity.

Whereas in our improvement to the above authors we are going to include sensors such as pH sensor, EC Sensor, Temperature & humidity sensor, CO2 Sensor, light intensity sensor along with the Ultrasound sensor, for collecting almost every nutritional and environmental parameter such as pH, TDS, temperature, humidity, CO2, water temperature, time, water level, light intensity, to get better accuracy in automation control.

3.2 Automation

The automation system of other authors has been compared here along with our proposed methodology. Water circulation can be considered a common part of the automation of the system where most of them consist of periodic circulation.

In **[3]** the authors have used Arduino mega board as the microcontroller for automation of their DWC hydroponic system where the microcontroller gets water pH data from the main tank and the Hydroponic tank as the only input data hereby controls the output devices such as solenoid valve, pH adjuster solution pumps, stirrer for mixing to maintain the pH of the water. Whereas in **[4]** the author has used a Microcomputer (Raspberry Pi) along with the use of a Microcontroller Arduino for retrieving data from sensors and manipulating the parameters for pH and TDS with Doser and humidity with Humidifier accordingly as the change is required. In **[5]** Automation was using a microcomputer running an RTOS which retrieves data from the sensors and controls the devices accordingly using the MIT MediaLab's OpenAg tool, The nutrition and pH dozing were managed by Microcomputer according to the data collected by the EC and pH sensors, the other parameters like light intensity, temperature, Humidity, CO2 was also controlled automatically by the Microcontroller. In **[6]** For automation, the authors used a Microcomputer to retrieve and manage the growth parameters like the previous author along with the oxygenation of water inside the main tank using air pumps.

In **[7]** the author has used Microcomputer (Raspberry Pi) for the automation along with the microcontroller to retain the accurate data from the sensors as the Microcomputer we will use won't have inbuilt analog IO pins. This automation can retrieve the pH, temperature, and water level data and manage those using PID controllers for more accuracy. Here in **[8]** for automation, the author has used three microcontrollers, two for retrieving data from the sensors and a third to transmit data, acting as a gateway to the microcomputer acting as a local server with Domoticz software for automation. In this automation periodic lightning is controlled using RTC (Real Time Clock), an air pump is used to infuse oxygen in water similar to the [6]apart from that the parameters controlled are pH, EC, water temperature with the monitoring of parameters explained in the previous section. The automation in **[10]** is done using a single microcontroller with an inbuilt Wi-Fi module that monitors pH, water levels, light ambiance, temperature & humidity and controls the parameters of pH, water level, and temperature along with the light intensity. In **[18]** the author has used a Microcomputer for the automation along with the three microcontrollers acting as nodes like **[8]** along with the Domoticz software for automation.

As compared to the above automation our automation system will consist of one microcontroller acting as a node between sensors and the microcomputer. This node is going to collect every growth parameter explained in the previous section, (i.e., pH and TDS of the nutrient solution/water, Water temperature, Temperature, Humidity, Light Ambiance, CO2) and send them to the Microcomputer using a serial connection. The microcomputer will next analyze the data received from the node using the program we will create and will then send it to the cloud server for UI and log purposes, the Analyzed data such as pH, TDS temperature, etc. will get displayed on an LCD connected to the System as well.

For automation, the microcomputer will control the external devices using the PID control program (which will be programmed by us) and the signals to relay switches to manipulate the growth parameters artificially until it gets into proper and stable ranges.

3.2.1 Auto Doser

For proper growth of a plant most important part which plays role in it is the pH of the medium along with the quantity of the Total dissolved Solvent where the plant roots are present **[21], [17]**, these two parameters are maintained by the auto doser system managed using the PID control the most commonly used controller system **[16]** accordingly as if the microcomputer founds any deficiency in TDS it will control the nutrient pumps relays A & B using PID control, these pumps will pour Nutrient according to the measured requirement periodically to avoid over dosage. Similarly, for pH, the PID control will also help in balancing it through the pH down (ACID) and pH up (BASE) pump relays, these will also occur periodically to avoid overdosing **[7]**. Another requirement for plant growth is the oxygen present in the growing medium which can be added artificially with the help of air pumps **[6]** also gets activated periodically through a microcomputer which starts and stops the relay switch.

3.2.2 External Devices

The microcomputer will carry out the task of manipulating/ controlling the other environmental factors as well. We will be using various devices for other parameters apart from the auto doser these include Temperature, Exhaust, Humidity, grow lights intensity, water level, and water flow. So that the environmental factors of plants growth will not get imbalanced.

(a)Temperature:
If the temperature data received from the temperature sensor is higher than the appropriate count the coolant relay will get activated until the temperature gets balanced and deactivate itself if the temperature doesn't rise rapidly **[15]**.

(b)CO2:
As the plants absorb the CO2 during the day and O2 during the night If the CO2 level rises the exhaust will activate until the CO2 level gets stable so that the plants can breathe properly it can also be used as a Ventilation system.

(c)Humidifier:
It will increase the humidity of the system if a humid environment is required as the microcomputer will detect the analyzed report from the sensor and then controls the humidity relay switch using PID control to provide humidity with better accuracy.

(d)Grow lights:
This NFT system will sustain both outdoor and indoor environments, if the system will be getting used indoors it won't be able to provide adequate light ambiance to the plants, here is when comes the role of GROW lights, it detects the intensity of light available through the sensor and the microcontroller will adjust the intensity accordingly using PID control so that the process of photosynthesis could not interrupt, it will be done both periodically and conditionally using PID control. This process will help the plants to get the chlorophyll 'a' and 'b' **[22]**.

(e)Water level:
One of the important parts of the NFT system is to maintain the water level inside the gullies where the plant net-pots are installed such that the water should be barely touching the bottom of the net-pot along with some air gap between them. As the inlet pump will always stay active from the relay, from which the water level will always tend to rise. to avoid overflow of water level, a Float switch and Ultrasound sensor will come into use as the microcomputer will be able to determine the height of the water using the analyzed data from the sensor and will control the water pump relay as required. If the water level is going to rise then it will deactivate the pump, the same thing will be done by the float switch which will directly disconnect the pump connection if the water level rises. Both are used together for better accuracy to maintain the water level inside the gullies of the system. Similarly, if the water level tends to get low, the microcontroller will activate the inlet pump relay to pump the water inside.

The inlet pump will always pump the water in a unidirectional way which can cause water to flow continuously to the end of the system where the outlet is located, the water outlet will also be connected with an outlet pump to avoid the continuous outlet flow of water and pump out the water only when required periodically so that the plants can absorb the nutrients for a certain time.

3.3 User Interface

Along with the automation, some authors have provided a user interface for monitoring and controlling the growth parameters.

In **[20],** the author has used ThingSpeakAPI to transmit the retrieved data from the sensors to the cloud storage for real-time remote monitoring, which will only represent Water level and Temperature data in an Android app named Virtuino. Whereas in **[9]**an IOS app has been developed for monitoring and control, along with the email and SMS support. In **[5]** mbedOS UI has been used for monitoring Realtime parameters. Here in **[4]**, again ThingSpeak API has been used for real-time cloud monitoring only, with the help of an Android application created through the MIT app inventor. **[7]** the author has used a web user interface for monitoring real-time data along with the logs, which can be accessed after login using a username and password. **[10]** unlike others**,** for real-time cloud support, firebase API is used which can be used in many platforms to access the data in Applications, few sensor parameters can also be controlled using the application. In **[8] [18]** the authors have used open source automation software called Domoticz for real-time cloud support, where data can be monitored in both the Web app and Android app along with the lights control.

With reference to **[7], [10]** we can develop a web user interface that can be used in Both Mobile and desktop environments in the form of a progressive web app (PWA). As the microcomputer will send the data to the Real-time cloud which can be accessed by the web user interface to reflect those data on the user dashboard. Also, the user can control the devices using the control buttons from the dashboard and the microcomputer will control the device relays accordingly.

3.4 Disease Detection

Apart from automation, we suggest disease and pest detection using Computer Vision and Deep Learning. with the help of large-quality datasets and transfer learning using architectures like Inception, ResNet, VGG, etc. we can train models to detect plant/leaf disease and pests along with their class type [**14**], with high accuracy and precision.

This can be done with the help of a dynamic camera connected which will be sending an image frame of a plant/leaf by detecting it using computer vision to the microcomputer for evaluation of the model, if a disease/pest gets detected the user will get notified through the PWA with the labeled image of the plant number and disease/pest type.

Pest management: for future purposes, we can implement several working techniques like ultrasonic/infrasonic sound to get rid of insects from the plants **[19].**

Using computer vision, we can also monitor the growth of the plant and maintain the nutrient requirement by getting data like yellow leaf colors, and stunted growth, and pump the appropriate nutrients accordingly.

4. Conclusion

We were able to discuss various Automated Hydroponics Systems and point out their features in this review paper. We have also suggested improvements to fulfill the drawbacks of other systems.

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