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IOT & ARTIFICIAL INTELLIGENCE BASED AUTOMATED SMART HYDROPONICS SYSTEM

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Abstract: High-quality food production for the human population is made possible by agriculture, which is the backbone of human civilization. Growing procedures are required to ensure the accessibility of affordable, high-quality crops to meet the rising food demand. However, using soil for agriculture traditionally involves a lot of space, a lot of labor, and a lot of water. These limitations are considered when conducting research on hydroponics, a soil-free growing method. This project aims to create an advanced IOT and AI-based hydroponic system to boost agricultural productivity. In order to ensure the proper and adequate utilities, the essential requirements: nutrients, sunlight, humidity, temperature, and water availability, are being examined using an experimental approach. ThingSpeak and MATLAB are used to evaluate the collected data. This setup makes it possible for the hydroponic system to function methodically, which is crucial and helps the user take the necessary action if necessary.

Index Terms - Internet of Things, AI, hydroponic system, NFT (Nutrient Film Technique)

1. Introduction

The practise of growing plants without soil by employing mineral nutrient solutions dissolved in water is known as hydroponics (Domingues et al. 2012). As said, plants are grown in a hydroponics system without using soil. A water-based, nutrient-rich solution, in which the water is combined with the prescribed plant solutions to thrive, provides all the nutrients that plants need to survive. Therefore, there are numerous hydroponic systems or techniques that allow plants to thrive either straight to the nutrient-enriched water-based solution or in a non-soil medium. These enterprises are systematically managed, and as a result, they typically produce more than traditional farming. This approach has been put into practise and employed in metropolitan areas for the past few years to increase access to fresh food.

The most plentiful medium for plant growth is the earth. Without the need of soil, plants or vegetables can be grown hydroponically by using mineral fertilizer solutions diluted with water. Since hydroponic growing techniques don't require soil and cities are growing rapidly, this helps justify their study and use. Land is being rapidly urbanised and cities are spreading. Hydroponics has a wide range of applications on Earth, and it will be quite valuable for future space flight. Plants grown hydroponically have their roots submerged in fertilizer solutions diluted with water. Compared to plants cultivated using the traditional method, this makes it much easier for them to obtain the necessary nutrients.

Artificial intelligence (AI) is a tool that gives computers the ability to function independently after receiving training for a specific activity (Kiani and Seyyedabbasi, 2018). First and foremost, a machine must first think and learn like a human person in order to think like a human mind. Human mind draws conclusions about the future from information and experiences from the past it is exposed to. The discipline of hydroponics makes use of the machine learning algorithm in a variety of ways. To build such a system, numerous devices will be connected to one another. An Arduino microcontroller was used for this study's major component since it is the most widely available.

A new study area with significant technical, economic and social implications is considered as the Internet of Things (IoT) (Kori et. al 2021). Automated smart hydroponics system that can add and incorporate IoT's capabilities to the currently in use hydroponics system. Through the application of IoT, system could be observed and managed remotely using the internet, allowing real-time monitoring of parameters including water temperature, pH level, room humidity, room temperature and nutrient-rich water-based solution temperature. Making decisions and sending commands from a user-friendly interface depending on the displayed real-time parameters is one of this system's primary characteristics.

2. Literature Review

The section examines the literature on Applications of IoT and AI to automate a hydroponic system to increase crops production. (Domingues et al. 2012) created an (AHS) Automated Hydroponic System which measures nutrients levels using pH, temperature, and electric conductivity as factors. Temperature, is a critical parameter since it affects pH and electric conductivity. Lettuce is grown with this system. Electric valves have been used in the proposed AHS (one for every nutrient). Study helped to keep the nutritional solution's pH level in check.

Pawar et. al (2019) had developed an IoT-based hydroponics system where the sensors are interfaced with a Wi-Fi module for monitoring. The automated part includes sprinklers for pests, humidity adjustment units, and pH up/down.

An automated closed (i.e., indoor) aquaponics was established in the study of (Saaid, et al. 2013). The device nourishes the fish, manages and monitors the water level and temperature, and is controlled by an Arduino Mega microcontroller. The pump is utilized for irrigating the water spinach of the system (Ipomoea aquatica) and spinach (Spinacia oleracea). Arif et al. (2017) constructed a system determining the plant’s age using a photo. The suggested system employs a Raspberry Pi 3 with camera module for collecting and processing the data, which is subsequently saved on the web server. The technology is being used in a hydroponic lettuce farm using NFT.

According to the literature review, the former system's shortcomings were that the automation created via IoT lacked intelligence in providing the right action of control for the learned parameters based hydroponic environment. Hydroponics' machine-level intelligence was not created for Internet of Things-based systems. The management of the hydroponic environment was not the main emphasis of the effort. As a result, the goal of this work is to create an intelligent IoT-based and cost-effective hydroponics system, where the control actions are based on real-time parameters acquired from the hydroponics system's sensors and makes it extremely beneficial for both urban and rural farmers.

3.Methodology

3.1 Materials & Methods

The basic block diagram for the automatic vertical hydroponic system comprises of six main parts including the power metre, the vertical hydroponic structure, main supply of power, control system and sensor, online database and a Wi-Fi module as shown in Figure.1. The monitoring of any sensor which is connected to the hydroponic system can be done with the use of an IoT platform on any of the smart devices. The module of power metre continually tracks power consumption, making the system more power-efficient and widely extendable. Each element of the block diagram is discussed below:

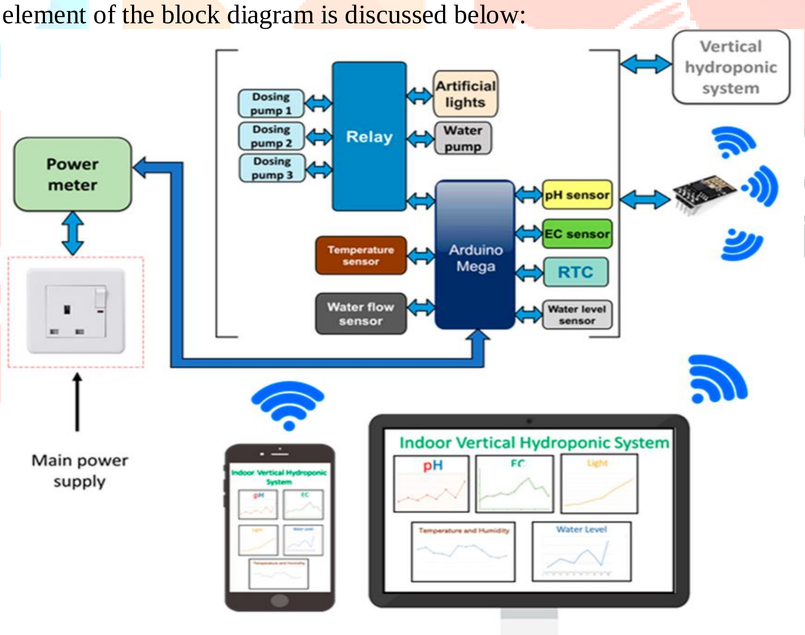

Figure 1: Block Diagram of Proposed System

Number of parameters including pH, ambient temperature, electric conductivity (EC), and container water level should be automatically and independently maintained by an automatic hydroponic system without the involvement of the user (Kiani and Seyyedabbasi, 2018). The microcontroller is equipped with a number of sensors to track these hydroponic system parameters. A control panel of an electromechanical relay manages artificial lights, dosing pumps and water pumps, used to add the nutrients and pH to the water. A Wi-Fi module of the type ESP 8266 was used to wirelessly transmit the complete data obtained from the core microcontroller circuit to the online database, Thingspeak, (Shanghai, China). The system's overall design is represented by the following subsections:

3.1.1 NFT architecture and key elements

In the Nutrient Film Technique (NFT) method, as shown in Figure 2, the reservoir is filled with nutrient solution, and the plants grow in channels called gullies (Kori et. Al 2021). The plant roots are kept wet by the thin coating of fertiliser solution. The roots at the bottom of the plant should be exposed to the fertiliser solution, and the top of the plant should ideally remain damp but not soggy. Similar to a stream delivering nutrients into a line, it works similarly.

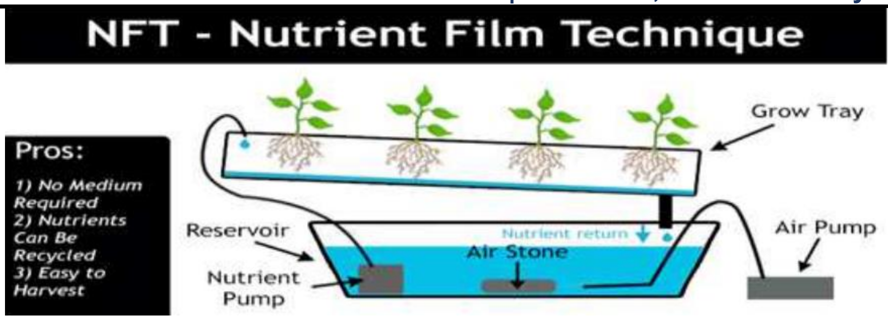

Figure 2: NFT (Nutrient Film Technique) Method (Kori et. al 2021)

1. **Water Flow Path**

It has been made with the aid of water pumps, containers, water level, EC, pH, temperature sensors and water flow.

2. **pH and Nutrition System**

The dosage pumps are housed in a special box. The electrical cables for dosing pumps can be attached to the microcontroller and relay using three holes on the back of the box (Elijah et. al 2018).

3. **Internet of Things (IoT)**

IoT stands for the Internet of Things, which aims to use the Internet to connect people and things while storing data in the cloud for analysis. Farmers may now automate hydroponic culture thanks to the development of IoT. IoT can be used to monitor and control things like water level, pH, temperature, and light intensity.

4.Experiment

The ESP8266 Wi-Fi module was used in the suggested technique to broadcast all sensor values, including pH, water level, EC, temperature and humidity sensors, as well as the system's consumption of power, to a web server. The Wi-Fi module and microcontroller are interconnected, and it is at the microcontroller that all sensor data is gathered and sent to Thingspeak, which is considered as an open-source platform for IoT. Because Thingspeak being an open source, supports MATLAB-based visualisation of data and algorithm application on the collected data, it is a fantastic option for an indoor vertical hydroponic system (Saaid et. Al 2015). The future of this effort will involve developing both conventional, IoT, and artificial intelligence methodologies, which is made simple by this framework. In addition, Thingspeak offers 8 distinct fields in which 8 different characteristics of system can be shown in the real-time without providing a membership fee, and also in the free version the channel is refreshed every 20s, which is adequate for our application. Furthermore, it is simple to configure a number of Android-compatible applications to allow the channel of the mobile application without any requirement of sign-in every time on the online browser to check the system settings. Consequently, a Thingspeak-based system is a wise alternative for building a profitable system with trustworthy IoT platform features. For further study, it also permits exporting the historical data in the CSV format, which is quite beneficial for prospective machine learning-based studies (Elijah et. al 2018).

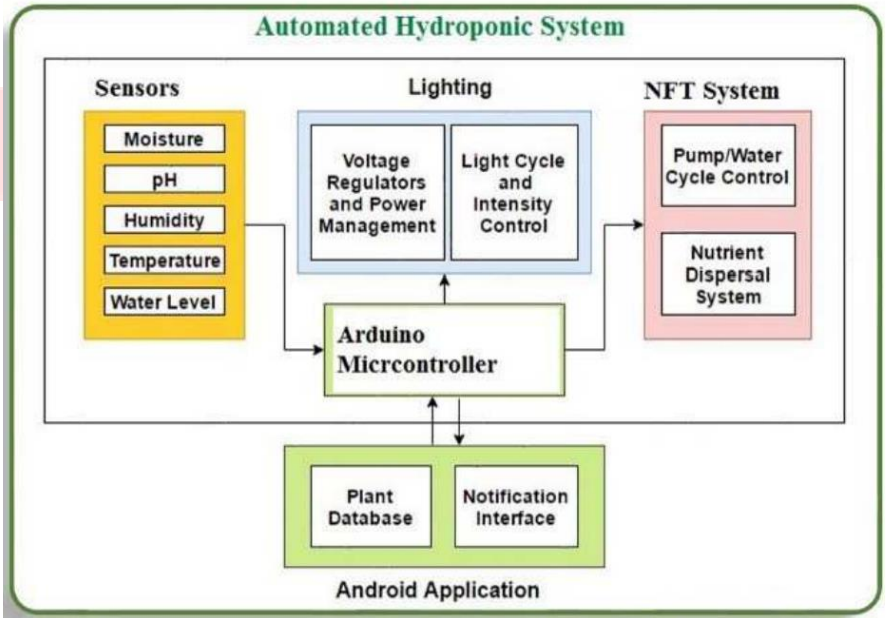

Figure 3: IoT based NFT System (Pawar et. al 2019)

Figure 3 depicts the block diagram of an IoT-based NFT system, where the sensor data output is controlled by an Arduino microcontroller. This information will then be displayed on an LCD panel and transmitted to an online database.

The system's brain, the Arduino controller, uses data to do calculations such as converting LDR values to Lux, running water motors, reading temperature, humidity, pH, and TDS, and sounding alerts. The water level is regularly checked by the controller. The controller again regulates the pH by adding nutrients if it changes after adding water. It monitors changes in temperature, humidity, and light intensity and notifies the user when the outside temperature or the water temperature rises. By connecting to Wi-Fi module, which is further attached to the router, the system delivers real-time data directly to the web. (Ezzahoui et. al 2021).

The algorithm is fed data from sensors including the humidity and the temperature sensor, pH sensor, water temperature sensor, water level sensor and Light Dependent Resistor (LDR). These values have a threshold that the algorithm has determined, and the appropriate operations are performed if the condition is met. The algorithm handles effectively and quickly turning on motor drivers when the sensor results are given to the processor. In this case, the ability to swiftly enable and disable motor drivers is essential. The Wi-Fi 802.11 standard must be used in this system for communication between an online database and microcontroller sensors. This Wi-Fi device will transmit information to a local router, which will then send it to a webpage for an online databank (Kiani and Seyyedabbasi, 2018).

5.Result & Conclusion

The Arduino controller uses a water tank, that serves as a reservoir and fills the water running to the necessary level, to operate the air and water pump when there is a water shortage in NFT system (Elijah et. al 2018). The water level is regularly checked by the controller. The controller will feed nutrients to return the pH to its previous value if it changes after adding water. When the temperature is rising in the immediate region or when water is running while the temperature, humidity, or light intensity are falling, the user is alerted. The system delivers real-time data straight to the web by connecting to Wi-Fi module, which is then connected to a router.

The system's online sheet, which can be accessed from any location in the globe and is used to operate the system, is used to upload data. The online scripting for Google Sheets, which could be set up as a web application and operates on Google server, allows one to get updated data and create graphs. The essential programming is finished, allowing the CPU to perform the required functions. It manages the movement of nutrients and water as well as the motors, which are driven by L293d motor driver IC (Ezzahoui et. al 2021). Additionally, the system is connected to an alarm that goes off when the sensor's value increases or decreases. A speaker that plays a certain sound or a number of connected LED lights could serve as the alarm (buzzer). This setting helps the user take the necessary actions when necessary and allows the hydroponic system to work in a methodical way, which is crucial. Farmers will improve their agricultural resources and operations by adopting these advanced technologies. The advancement of such advanced technology will pave the way for long-term agricultural sustainability.

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