iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VI **Month of publication:** June 2023

DOI: https://doi.org/10.22214/ijraset.2023.54443

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Smart Hydroponic System and Monitoring of Plant's Health through Machine Learning

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Abstract: In recent years, there has been a growing interest in hydroponic systems as a means of growing crops in controlled environments. However, traditional hydroponic systems require manual monitoring and adjustment of various parameters, such as light, temperature, and nutrient levels, to maintain optimal plant growth conditions. In this paper, we propose an IoT-based smart hydroponic system equipped solar module for backup that automates the monitoring and control of these parameters to improve the efficiency and success rate of hydroponic crop production.

The proposed system incorporates an image processing component that uses a camera to monitor the health of the plants and detect any signs of stress or disease. The images are processed using computer vision algorithms to extract relevant features, such as the color and texture of the leaves, which are used to determine the plant's overall health.

Keywords: Hydroponic, Nutrient, Image processing, Algorithms, and Solar module.

I. INTRODUCTION

Hydroponic systems are becoming an increasingly popular method of growing plants, as they can provide a controlled environment that reduces the need for traditional soil-based agriculture. Hydroponic systems can be set up in greenhouses, indoor farms, or other controlled environments, and use nutrient-rich water to support plant growth. However, hydroponic systems can be challenging to maintain, as they require careful monitoring of water quality, nutrient levels, and plant health to ensure optimal growth.

To address these challenges, this paper proposes an IoT-based smart hydroponic system that uses image processing to monitor plant health. The system uses sensors to monitor environmental parameters such as temperature, humidity, and light intensity and adjusts the water flow and nutrient levels accordingly. Image processing is used to monitor plant health by analyzing the color and shape of the leaves, as well as other plant characteristics. The system is equipped with a camera that captures images of the plants and uses machine learning algorithms to analyze the images, providing real-time information about plant health and growth.

In addition to image processing, the system includes sensors for monitoring environmental factors, such as temperature, humidity, and nutrient levels, as well as actuators for controlling the hydroponic system, such as pumps for delivering water and nutrients to the plants. The data from the sensors is transmitted to a cloud-based server, where it is analyzed to determine the best course of action to maintain optimal growing conditions for the plants.

The results of preliminary tests could show that the proposed system is capable of accurately monitoring the health of the plants and providing real-time feedback on the growing conditions. The system can also automatically adjust the hydroponic parameters to maintain optimal growing conditions, resulting in improved plant growth and higher crop yields.

II. LITERATURE SURVEY

The paper by [1] Ravi Lakshmanan et al., discusses that to make the process of growing and monitoring food hydroponically easier, the Internet of Things concept has been integrated into the system. By offering a platform for monitoring the entire system from the cloud and lowering the cost of maintenance by a little amount, the Internet of Things addresses one of the major issues with automation that exists today: maintenance.

[2] Mohanty et al., 2016 approach Using a public dataset of 54,306 images of diseased and healthy plant leaves collected under controlled conditions, they trained a deep convolutional neural network to identify 14 crop species and 26 diseases. The trained model achieves an accuracy of 99.35% on a held-out test set, demonstrating the feasibility of their approach.

[3] Muhammad E. H. Chowdhury et al., have created a hydroponic system with machine learning algorithms that can be aided by the IoT platform's ability to extract data into CSV files, and the system can generate a significant volume of data appropriate for training both classical and deep learning algorithms to improve the performance of automated systems for regulating. The option of doing several other investigations has been made possible by this study. Through this wireless platform, it is also possible to study and track the comparative growth of field plants and organic plants.

[4] The aim of the study is to create an Arduino microcontroller-based control tool that uses a smartphone to autonomously control the delivery of nutrients to hydroponic plants. They have employed logical if else to automatically control the flow of nutritional solution using an Arduino Uno microcontroller. The microcontroller can also convey information about the fluid level (solution) and surrounding plant temperature to the hydroponics plant owner's Android smartphone. The temperature sensor LM35 and the ultrasonic sensor HC-SR04 measure the height of the water-based nutrition solution, respectively. The Arduino Uno will receive data from the sensor and display it on a liquid crystal display (LCD), after which an ESP8266 module connected to WiFi will broadcast the height of the nutritional solution and other data.

III. METHODOLOGY

The IoT-based smart hydroponic system consists of several components, including a microcontroller, sensors, cameras, and a cloud platform for data storage and analysis. The microcontroller, such as a Raspberry pi, collects and processes data from the sensors and cameras and controls the hydroponic system's various components.

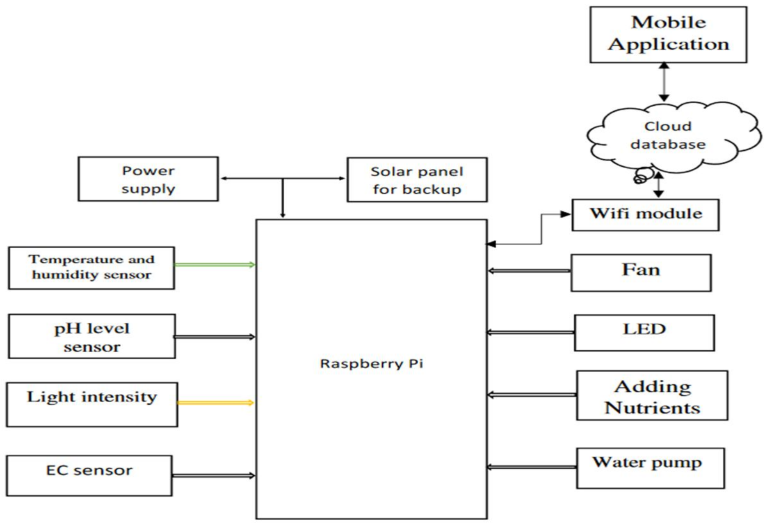

Fig. 1 Block diagram of hydroponic system

Sensors, such as temperature and humidity sensors, are used to monitor the environment in which the plants are growing. The cameras, which are positioned above the plants, capture images of the plants at regular intervals and transmit the images to the microcontroller for analysis. The image processing algorithms used in the system are designed to detect various characteristics of the plants, such as the color, shape, and texture of the leaves. The algorithms then analyze these characteristics to determine the overall health of the plants and identify any potential issues, such as nutrient deficiencies or pests.
The results of the image processing analysis are then transmitted to the cloud platform, where they are stored and analyzed. Farmers can access the data through a web interface, which provides real-time information on the health of the plants and allows them to make informed decisions about how to adjust the hydroponic system to optimize plant growth.

IV. RESULTS AND PERSPECTIVES

The IoT-based smart hydroponic system has been tested on a variety of plant species and has shown promising results. The system was able to accurately monitor environmental parameters such as temperature, humidity, and light intensity, and adjust the water flow and nutrient levels accordingly. The image processing algorithms were also able to accurately predict plant health, providing real-time information about the status of the plants.
The hydroponic system developed by Ravi Lakshmanan et al. will be able to add and implement the Internet of Things concept and functionality to the current existing hydroponics system.
Once the smart hydroponic system is in working condition, we implement time-lapse photography which takes photos every two to three hours to monitor the health of the leaves, the machine learning algorithm can be implemented and train the model with plant village datasets that are available on the internet as open plant data source for data science. The model is tested and trained for the plant village database.

There were several vertical hydroponic systems available, including the A-frame, Zig-zag, vertical hydroponic tower, ZipGrow tower, and vertical Nutrient Film Technique (NFT) system. The idea and design of the vertical NFT system which I have chosen for this study are among the several vertical hydroponic systems that are currently available. It is because of the straightforward design, ease of assembly, simple configuration, high plant production in a short space, and strong supporting system that holds the whole structure.

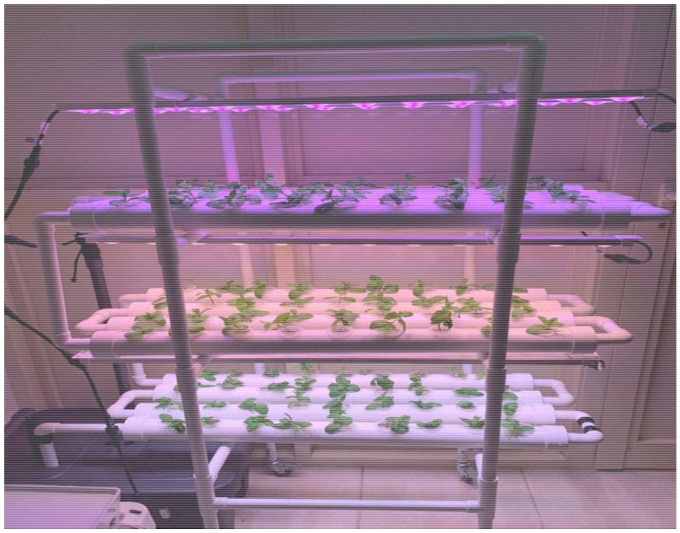

Fig. 2 Muhammad E. H. Chowdhury, Amith Khandakar, Saba Ahmed, et al. *Sensors* 2020, *20*(19), 5637; https://doi.org/10.3390/s20195637

In this automated system, the microcontroller can control and monitor all the sensors connected to the hydroponic system. All the acquired data from the microcontroller circuit were sent wirelessly to an online database through a Wi-Fi module.
The technology was initially employed for planting mint from a stem in an enclosed space after the sensors and system modules had undergone calibration and testing. and later on, used to plant tomatoes, strawberries, mint, coriander, cucumber, capsicum, and lettuce. The development of continuous power monitoring and an AC controlling module for the hydroponic system was one of the work's most significant accomplishments.

V. CONCLUSION

The IoT-based smart hydroponic system discussed in this paper has the potential to revolutionize the way that hydroponic farming is conducted. By using image processing to monitor the health of the plants, the system provides farmers with real-time information that can be used to optimize the growing conditions and increase productivity. The use of sensors and cameras also makes the system more efficient and less prone to human error than traditional methods of monitoring plant health.
In conclusion, the system has the potential to improve the efficiency and success rate of hydroponic agriculture by automating the monitoring and control of various parameters, including the health of the plants, to maintain optimal growing conditions. Further research is needed to improve the accuracy and robustness of the image processing algorithms and evaluate the system's performance under different growing conditions.

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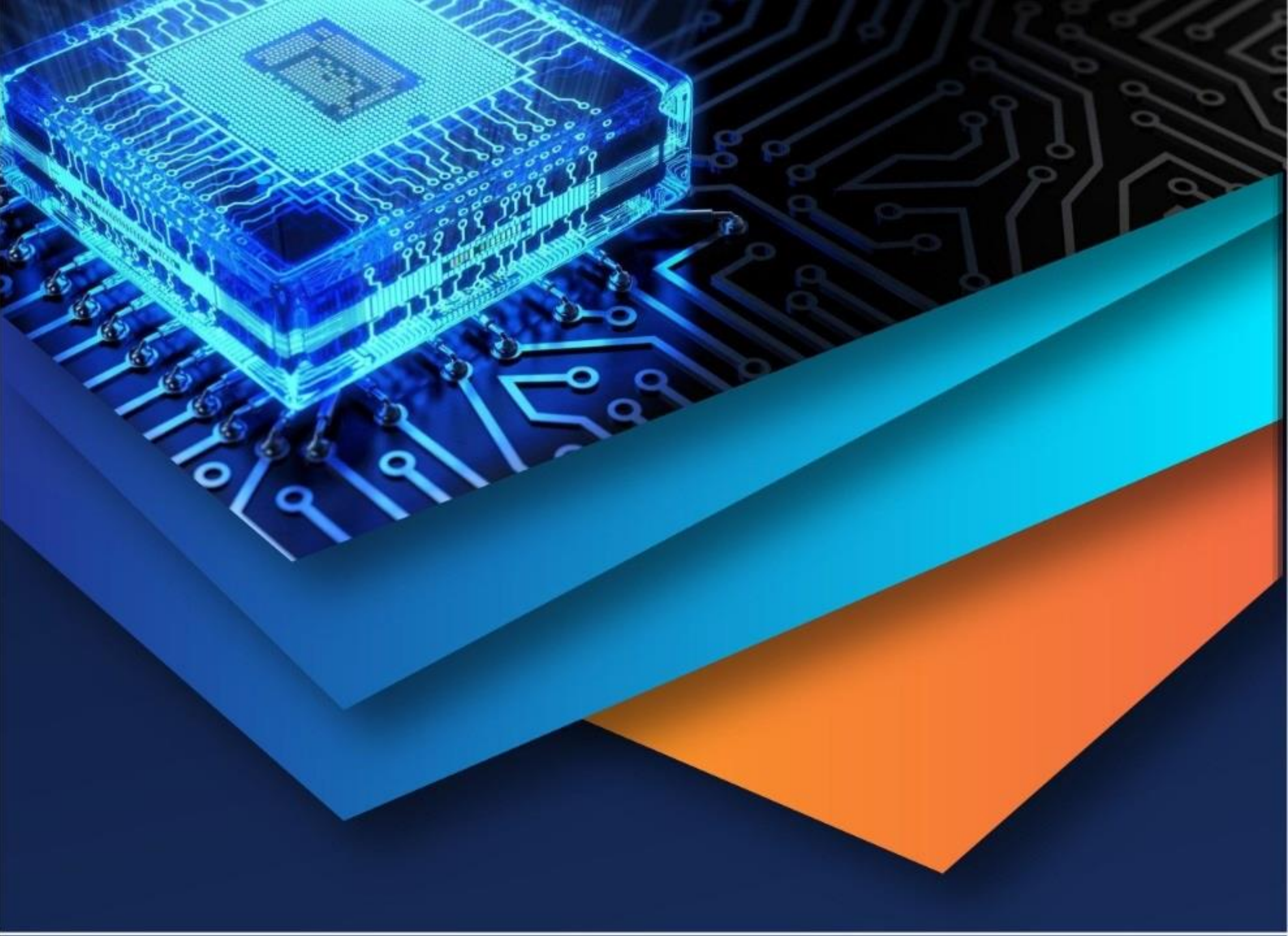

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