Automatic Hydroponic Farming System with Image Processing based on Nutrients System

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ABSTRACT

This project introduces an advanced automated hydroponic farming system that integrates image processing and precise nutrient management to support optimized plant growth. In hydroponics, plants grow without soil, relying instead on a nutrient-rich water solution. The core of the system involves real-time image analysis to assess plant health and detect nutrient deficiencies. Using computer vision image processing techniques, images of the plants are analyzed to identify key indicators of health, including leaf colour, size, shape, and texture. Based on these assessments, the system can send alerts messages to user and can automatically adjust the concentration of nutrients in the solution to maintain optimal plant health. Additionally, it monitors and automatically adjusts other crucial parameters like pH level, temperature and humidity, and light intensity, which are essential for nutrient uptake and overall growth.

Keywords- Raspberry Pi, Hydroponics, Automated system, Mobile Application, Sensors

INTRODUCTION

The Greek words "hydro" (which means water) and "ponos" (which means labour) are the roots of the word "hydroponics." A new farming method called hydroponics produces crops without the use of soil via nutrient solutions. Automatic hydroponics farming system with image processing-based on nutrients system is an advanced approach to growing plants without the use of soil. Hydroponic systems are becoming increasingly popular due to their numerous advantages over traditional soil-based agriculture they offer precise control over environmental factors reduce water usage and can increase crop yield and quality.

The proposed system employs image processing to analyse the plant's growth and determine their nutrients requirements. A camera captures images of the plants at regular intervals and image processing algorithms analyse the images to identify various growth parameters such as plant height, leaf area, and colour. Based on this analysis the system send alerts messages to used and can automatically adjusts the nutrient supply to ensure that the plants always receive optimal nutrition. The system is also fully automated reducing the need for manual intervention and making it ideal for large-scale commercial operations. This system monitors and automatically adjusts other crucial parameters like pH level, temperature and humidity, and light intensity, which are essential for the overall growth.

An integrated approach can enhance resource efficiency, reduce waste, and improve agricultural productivity. By leveraging the strengths of both systems, it is possible to create a more sustainable and resilient farming model. This integrated system can solve contemporary agricultural challenges, such as water scarcity, the need for reduced chemical inputs, and the quest for increased food production. This research aims to explore the potential of synergizing hydroponic and aquaponic technologies to create a hybrid farming system that maximizes resource use and productivity.

RELATED WORK

Suhan M, Surya Murali , Shriram Bharadwaj T et.al, This paper, an integrated Internet of Things (IoT) framework is proposed for controlling and managing the hydroponics garden. System used for continuous monitoring of pH, water level, temperature, and humidity. Information is processed, controlled, and exchanged internally via the Internet collected by the sensors and the use of cloud-based technology as the backend. [1]

Sonashree T., Suprabha G ,Vachanshree, Chaithra.A et.al This project presents the development and implementation of an Internet of Things (IoT)-based 5 hydroponics system merged with machine learning algorithms. Sensors deployed in the hydroponic setup collect real-time details, which is then examined using machine learning models to predict the optimal growth of the plants. the integration of IoT allows remote monitoring and control via a user-friendly interface, providing notifications and actionable insights to the user. [2].

Akanksha Kadu, Ankit Bais, Ansh Monga, Mrunmai Jawalekar et al describes the use of IoT in hydroponic farming, it is practically emphasis on remote monitoring and control systems. The report delves into the benefits, challenges, and potential future developments of utilizing IoT for efficient agricultural practices. The integration of Internet of Things (IoT) technology further elevates hydroponic farming, enabling precise monitoring and control of crucial parameters such as nutrient levels, temperature, humidity, pH balance, and light exposure. It highlights the benefits of IoT in hydroponic farming, also addressing the challenges posed by connectivity, data security, and cost. [3]

Ramakrishnam Raju, Bhasker Dappuri et.al focuses on implementation of android application integrated AI based smart hydroponics expert system. The proposed AISHES with IoT consists of three phases, where the first phase implements hardware environment equipped with real-time sensors such as NPK soil, sunlight, turbidity, pH, temperature, water level, and camera module which are controlled by Raspberry Pi processor. The second phase implements deep learning convolutional neural network model for best nutrient level prediction and plant disease detection and classification. In third phase, farmers can monitor the sensor data and plant leaf disease status using an Android-based application, which is connected over IoT environment. In this manner, the farmer can continuously track the status of his field using the android app [4].

Huu Cuong Nguyena, Bich Thuy Vo Thi, Quang Hieu Ngoc et al report on the design and development of an automatic hydroponic farming based on the IOT technique. This system allows sensor data to be collected in real time. An IoT gateway and virtual server are developed to transmit this real-time data to the cloud and store it. Via the web interface, the user can observe all the sensor data, as well as control the farming equipment. The system has been tested and evaluated during lettuce growth in an NFT hydroponic system. [5]

Dhruvkumar Sanjaybhai Patel et al presents an automated irrigation system for Hydroponic farming based on IoT sensors which are integrated with plant lifecycle monitoring through image processing Hydroponic farming. This system uses image processing to comment on plant health status based on controller will be decided to the amount of nutrients should supply this process makes the irrigation system and nutrients system automatic and can be used by ruler farmer without the need of learning botany in depth..[6]

Md Anisur Rahman, Narayan Ranjan Chakraborty, Abu Sufiun, Sumit Kumar Banshal, Fowzia Rahman Tajnin et al Artificial Intelligence and the Internet of Things, have emerged as pivotal tools in automating processes, providing alerts messages, and monitoring agricultural activities to optimize results. To ensure optimal resource allocation and maximize yields we have used machine learning models and trained them to recommend suitable crops from the given parameters and also recommend the changes in parameters that are needed for better plant growth.[7]

Pradnya Vishram Kulkarni, Dr. Vinaya Gohokar, Mr Kunal Kulkarni et al system integrates a wireless sensor network and Internet of Things (IoT) connectivity, including ESP32 microcontrollers as the primary unit alongside complementary hardware components which does real-time monitoring of critical nutrient parameters. Through a thorough examination of the extensive dataset gathered via deployed sensors, the study unveils variations in environmental parameters throughout various stages of plant development, including germination and root establishment. Results show higher Total Dissolved Solids (TDS) values correlate with better plant growth, while reduced pH levels harm plants. These findings are crucial for interpreting diseases in plants, aiding farmers in identifying issues early and optimizing yields. [8]

Sudharsan S, Vargunan R, Vignesh Raj S, Selvanayagan S et al this which is fully automatic hydroponic system that can be integrated into the agricultural while introducing business skills. The automatic monitoring and control of the environmental events is carried out by lodging sensors and actuators onto the system. The maintenance and automated monitoring are done by the IoT that are used to transfer and retrieve data to the internet (mass storage) and a mobile app is used to communicate the current status of the hydroponic system to the user through the use of internet to their mobile phones.[9]

M A Alim Ahmed, S Madhava Reddy et al propose an IoT-based smart hydroponic system equipped solar module for backup that will automates the monitor and control the parameters such as light, temperature, and nutrient levels to improve the efficiency and success rate of hydroponic crop production. It uses a camera to monitor the health of the plants and detect any signs of stress or disease. The images processing algorithms are used to extract relevant features, such as the colour and texture of the leaves, which are used to determine the plant's overall health.[10]

BLOCK DIAGRAM OF SYSTEM

Fig.1 shows a Block diagram of an existing system by using Raspberry Pi and sensors. The main controlling operation is carried out in given system is Raspberry Pi which is interfaced with different input and output components which is briefly explained in the following ways,

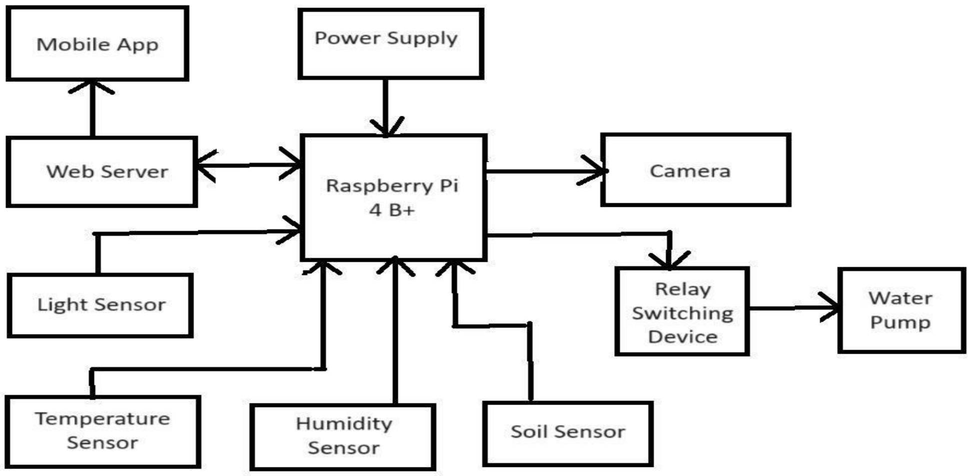

Figure 1: *Block Diagram of System.*

This block diagram represents an automated irrigation or monitoring system centered around the Raspberry Pi 4 B+ as the main control unit. The Raspberry Pi serves as the processing hub, receiving data from various sensors and controlling connected devices like a water pump through a relay. The system is equipped with multiple sensors to monitor environmental conditions. A temperature sensor measures the ambient temperature, while a humidity sensor monitors the air's moisture content. The soil sensor detects soil moisture levels to determine if irrigation is necessary, and a light sensor measures light intensity, which can help ensure proper lighting for plants or control artificial lighting systems.

A camera is included to capture live images or videos for monitoring plant growth or detecting issues such as pest infestations. The captured data can be analyzed locally on the Raspberry Pi or sent to a connected web server for remote access

The relay switching device acts as an interface between the Raspberry Pi and the water pump, enabling or disabling the pump based on commands issued by the Raspberry Pi, typically in response to soil moisture readings.

The system also includes a web server that stores and processes data from the Raspberry Pi, providing a platform for remote monitoring and control. A mobile app interfaces with the web server, allowing users to monitor sensor readings, view camera feeds, and control the system remotely. Users can also override automated controls, such as manually activating the water pump, via the app. Lastly, a power supply provides the necessary energy to power the Raspberry Pi and all connected components.

FLOW CHART OF SYSTEM

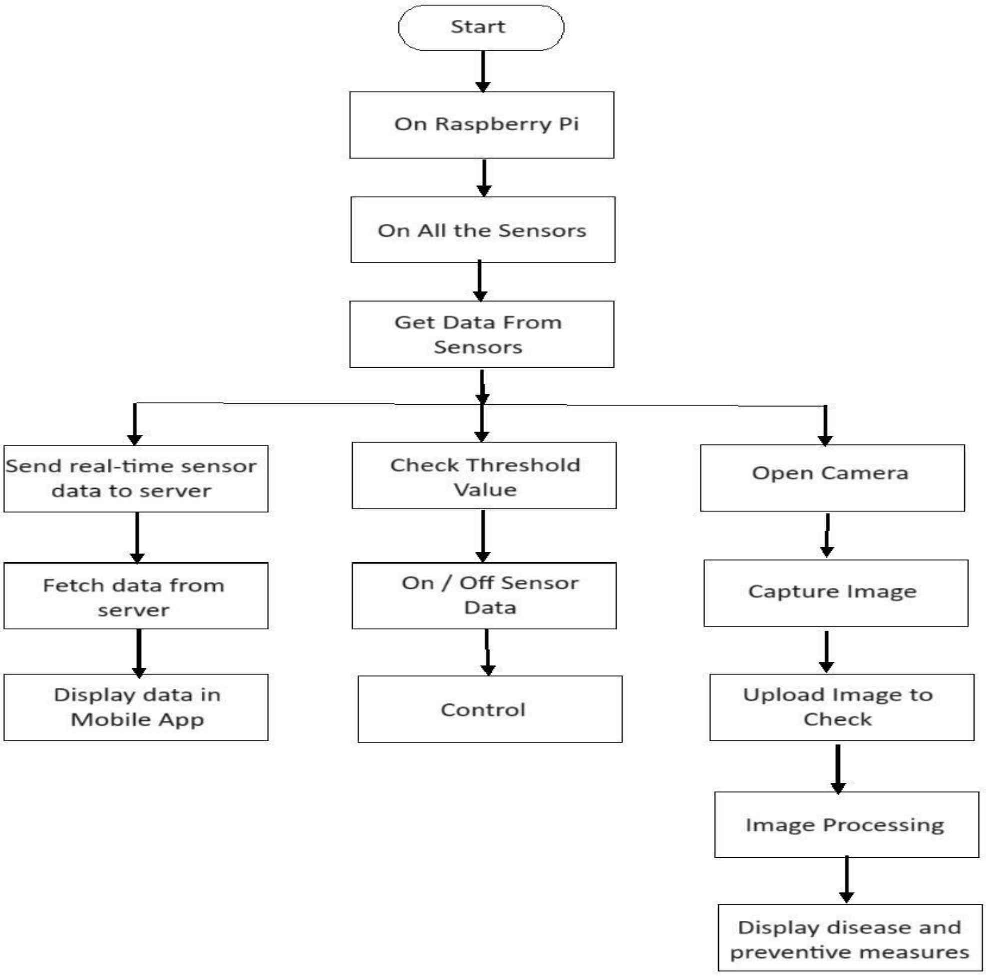

Figure 2: *Flow chart of the system*

The flowchart outlines the workflow of a smart monitoring and control system using Raspberry Pi. The process begins with powering on the Raspberry Pi, followed by activating all connected sensors. The sensors collect environmental data, which is processed in three main paths.

First, the real-time sensor data is sent to a server and retrieved for display in a mobile app, allowing remote monitoring. Second, the system checks sensor data against predefined threshold values. If the data exceeds or falls below the thresholds, appropriate actions are taken, such as turning devices on or off to maintain optimal conditions. Lastly, the camera is activated to capture images. These images are uploaded for processing to detect diseases or anomalies in plants. After processing, the system displays the detected issues and suggests preventive measures.

This integrated approach combines real-time monitoring, automated control, and image-based diagnostics to ensure efficient management of environmental conditions.

SOFTWARE RESULT

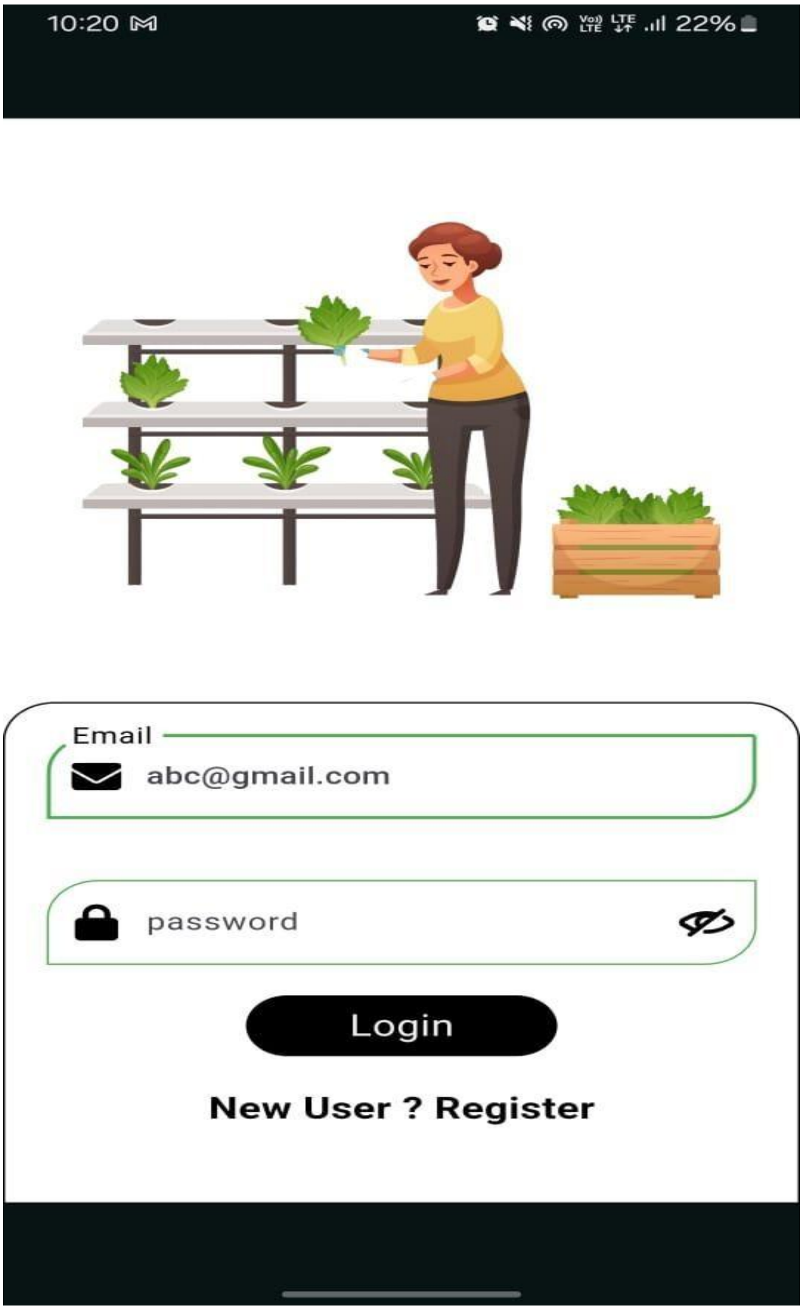

Figure 3: *Software Result Login Page.*

Fig. 3 shows that the Login Page for the user to log in into Android application from which user can monitor and control the system.

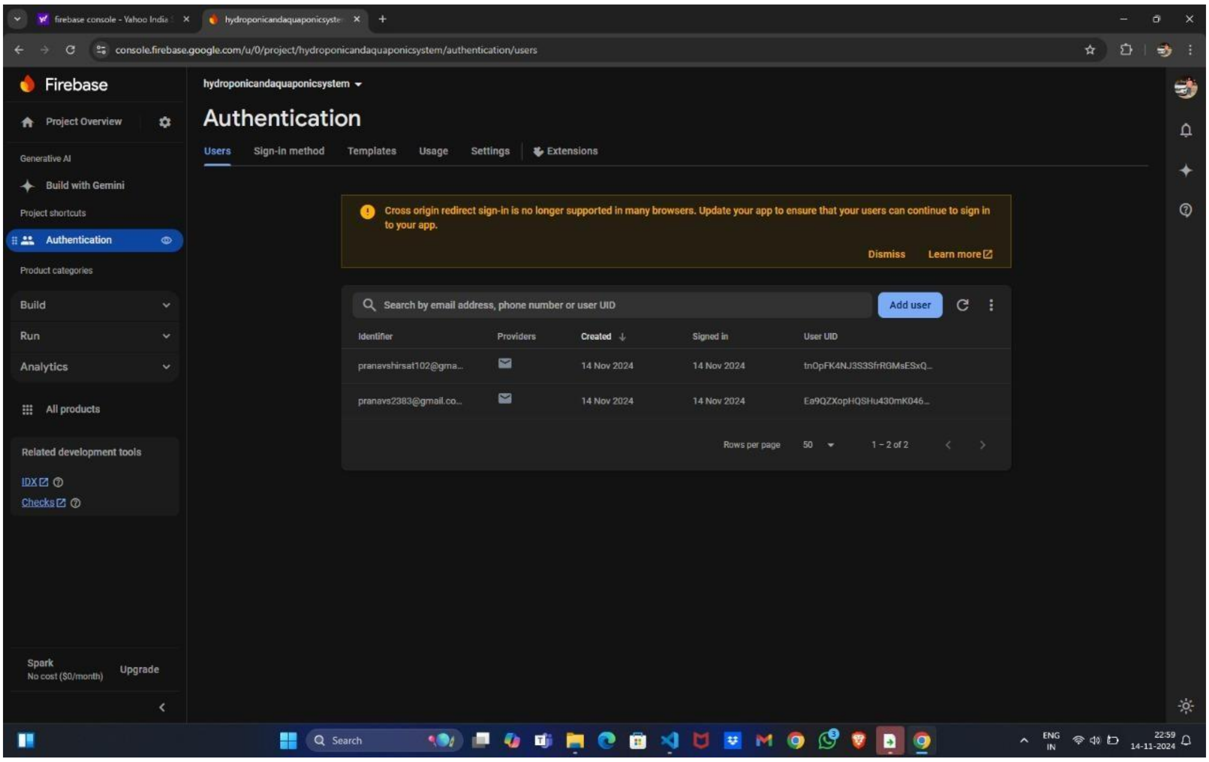

Figure 4: *Software result of Database Connectivity.*

Fig. 4 shows that the database of registered users. After the login and register all the data of users will store in firebase which will view like this.

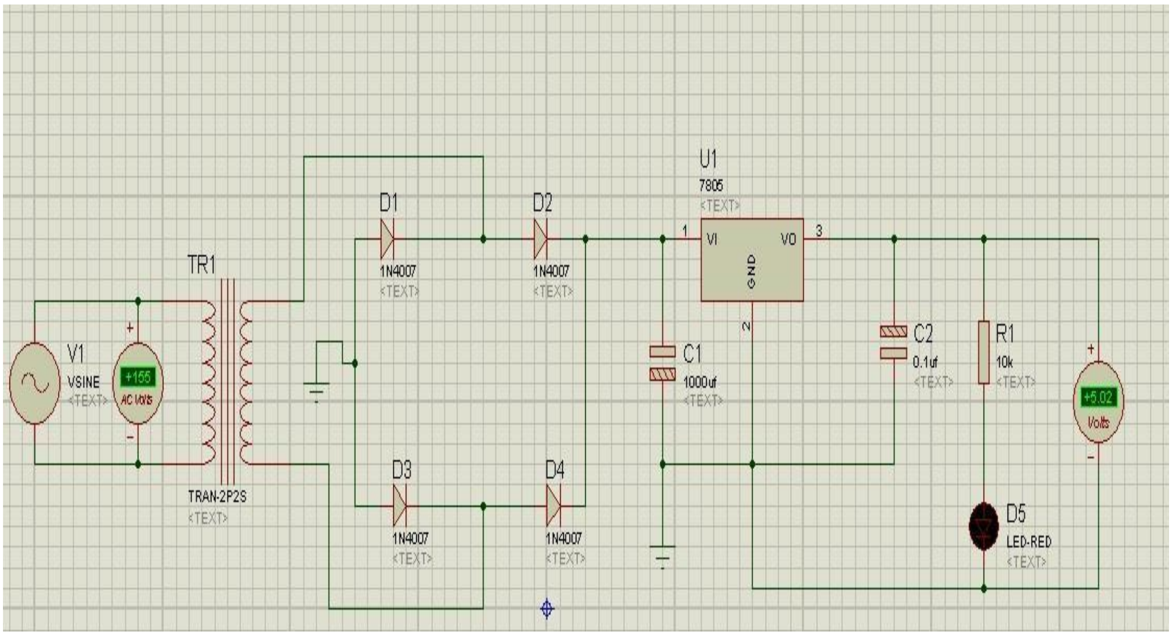

Figure 5: *Software Simulink result of 5V Power supply.*

Fig. 5 shows that the software Simulink results in DC 5V power supply using proteus software.

CONCLUSION

In this paper, we proposed a method for an Automation system for automated hydroponic farming system with image processing based on nutrients is used to reducing human efforts. It promotes high crop yields and efficient water usage, making it a viable, eco-friendly alternative to traditional farming. Overall, this approach is a powerful advancement in sustainable agriculture, merging technology with natural processes to create a resilient, high-performance farming solution for the future.

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