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# SMART CULTIVATION ANARDUINO BASED IOT AEROPONICS SYSTEM FOR INDOOR FARMING WITH LEAF DISEASE DETECTION

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## ABSTRACT

Agriculture plays a crucial role in India, providing livelihoods and contributing significantly to the national economy. Plant health directly impacts crop yields and farmer income. Continuous monitoring is essential to detect diseases early and prevent crop losses.

**KEYWORDS:** Vertical Farming, Sustainable Food Production, Climate Stress, Technological Innovation, LED Lighting Systems, Automated Hydroponic Cultivation, Design Solutions, Resilience, Circularity, Water Quality

## 1. INTRODUCTION

Global population is rapidly increasing, placing substantial pressure on traditional agricultural the methods to fulfil the rising food demand. Concurrently, climate-related stresses— such as extreme weather and changing environmental conditions—pose major challenges to the stability of food production. In response, vertical farming has emerged as a promising innovation for sustainable food production, potentially feeding the growing population while mitigating agriculture's vulnerability to climate change. Early advancements in vertical farming were largely driven by technology, including sophisticated LED lighting, automated hydroponic systems, and innovative space- efficient designs. These have greatly improved indoor farming, enabled year- round cultivation and reduced dependence on climate-sensitive traditional farming. As vertical farming evolves, research is increasingly focused on two key factors: resilience and circularity. Resilience refers to a system's capacity to withstand and recover from stresses like pests, diseases, and extreme weather .Circularity emphasizes sustainable, regenerative practices that minimize waste and resource use, promoting a closed-loop agricultural ecosystem. A central research area is the quality of water and microbial life in hydroponic systems, vital components of vertical farming. Plant Growth Promoting Rhizobacteria (PGPR) have been studied for their role in boosting plant health and resilience against stresses. Introducing PGPR increases microbial diversity, reducing reliance on chemical fertilizers and pesticides, thus supporting sustainability goals. This paper offers a comprehensive overview of vertical farming, tracing its origins and discussing its economic, environmental, social, and political opportunities and challenges. It also explores recent advances in leveraging the rhizosphere microbiome in hydroponic systems to improve circularity and resilience. In India, agriculture remains the primary occupation of rural villagers. While mechanical and chemical innovations have improved yields and addressed crop diseases, digitization in agriculture has been limited. The rise of the Internet of Things (IoT) inspires hope for creating digital systems to aid farmers in making informed decisions and anticipating problems, thus enhancing crop quality and benefiting farmers.

Research Paper

## 2. LITRATURESURVEY

[1]. Reimagining Farming: An Arduino-Powered IoT Aeroponics System for Indoor Cultivation by A. Patel, R. Gupta, S. Sharma in 2019. This research presents an innovative and advanced IoT aeroponics system tailored for indoor cultivation, driven by Arduino technology. The system introduces a paradigm shift in smart farming practices by integrating cutting-edge sensors that continuously monitor and optimize the indoor environmental conditions. Actuators are employed to precisely control irrigation and lighting, ensuring optimal growth conditions for crops. Moreover, the organization be located fortified through internet connectivity, allowing real-time data access remotely. This seamless integration of technology fosters an efficient and sustainable approach to indoor crop cultivation, offering potential solutions to food security challenges cutting-edge the appearance of a changing climate. [2] Towards Sustainable Vertical Farming: An IoT Enhanced Aeroponics System by L. Wang, C. Li, K. Zhang in 2021. This article presents an innovative IoT-enhanced aeroponics system aimed at fostering sustainable vertical farming practices. Utilizing a network of sensors, the system intelligently tracks the indoor farming environment, while actuators efficiently manage irrigation and lighting. By combining IoT technology with aeroponics, this approach strives to optimize plant growth, resource usage, and overall productivity. [3] Enhancing Crop Resilience: An IoT-Driven Automated Aeroponics Solution by J. Lee, K. Kim, H. Park in 2023. This study details the design and implementation of an IoT- driven automated aeroponics solution with a focus on enhancing crop resilience. Through the integration of advanced sensors and actuators, the system effectively monitors and controls the growing environment, promoting optimal plant health and adaptability to varying stresses. By empowering farmers with remote data access, this approach contributes to sustainable and climate resilient indoor farming. [4] Intelligent Cultivation: An IoT-based Aeroponics System for Precision Farming by M. Anderson, S. Thompson, R. Martinez in 2020. This research showcases an intelligent IoT-based aeroponics system tailored for precision farming in indoor environments. Leveraging state-of-the-art sensors and actuators, the system autonomously regulates crucial factors like irrigation and lighting to achieve optimal growth conditions. By integrating artificial intelligence, the system further refines cultivation practices, enabling resource- efficient and sustainable indoor crop production.[5] Data-Driven Indoor Agriculture: IoT-controlled Aeroponics System for High- Yield Crops by A. Smith, E. Johnson, T. Miller in 2021. This paper presents a data-driven approach to indoor agriculture, featuring an IoT-controlled aeroponics system designed for high-yield crop production. Advanced sensors provide real-time insights into the growing environment, allowing actuators to dynamically adjust irrigation and lighting. With its data-centric approach, this system maximizes crop yields, promotes resource conservation, and advances the sustainability of indoor farming.

## 3. EXISTINGSYSTEM

In existing method, uses Support Vector Machine algorithm for tomato leaf disease detection. However, SVM's reliance on handcrafted features and its struggle with high- dimensional image data limit its effectiveness. The need for manual parameter tuning and kernel selection adds complexity and time consumption. Additionally, SVM's rigid decision boundaries may miss subtle disease patterns, leading to suboptimal accuracy. Moreover, SVM lacks inherent adaptability to changing disease variations. These drawbacks highlight the need to explore more advanced techniques like CNNs to achieve better accuracy and automation in tomato leaf disease detection.

## 4. PROPOSEDSYSTEM

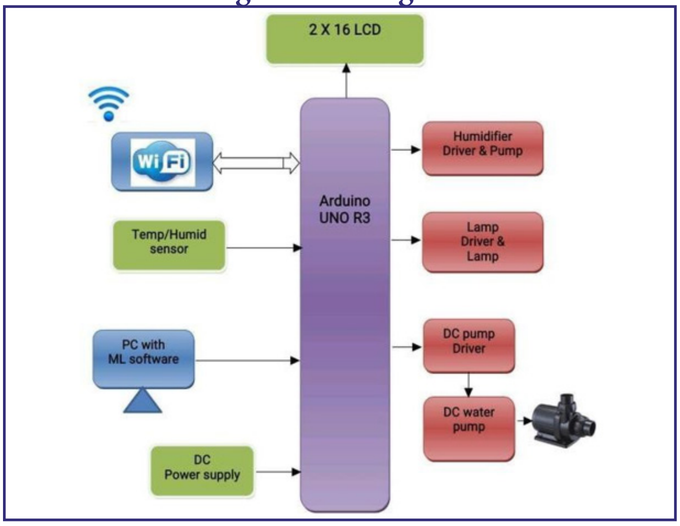
The proposed system employs Convolutional Neural Networks, a cutting-edge deep learning approach renowned for its efficiency in image tasks. By automatically learning features from raw images, CNNs eliminate manual feature engineering. Their architecture captures intricate disease details, superior to traditional methods like SVM. CNNs adapt well to diverse disease variations, offering robustness through transfer learning. Their accuracy, automation, and adaptability make them highly efficient for precise tomato leaf disease detection, outperforming conventional techniques.

## 5. METHODLOGY

This project utilizes a modular IoT framework cantered around an Arduino microcontroller. Various sensors—including DHT11 for temperature and humidity, pH, NPK, and light sensors—continuously gather environmental data. Actuators manage mist nozzles, nutrient pumps, and LED lighting within the aeroponics chamber. Data communication occurs via Wi- Fi module (e.g., ESP 8266) to a cloud-based IoT dashboard, enabling remote monitoring and environmental control.

The control system operates with a closed-loop logic: when parameters like humidity, nutrient concentration, or pH deviate from set thresholds, the system triggers corrective actions such as activating humidifiers, water pumps, or nutrient injectors. Live measurements of temperature, humidity, and nutrient balance are displayed on an LCD or mobile dashboard. For disease detection, the system employs Convolutional Neural Networks (CNNs), an advanced deep learning technique well-suited for image analysis. CNNs automatically extract features from raw images, removing the need for manual feature engineering. Their layered architecture captures detailed disease characteristics more effectively than traditional classifiers like Support Vector Machines (SVMs). CNNs also adapt well to various disease patterns through transfer learning, offering robust, accurate, and automated detection of tomato leaf diseases.

**Fig. Block Diagram**




This block diagram illustrates an automated environment control system, likely for a greenhouse or indoor garden, centered around anArduinoUNOR3.Thesystemusesvarious sensors to monitor conditions and actuators to maintain them based on programmed logic or machine learning. Arduino UNO R3: The central micro controller that receives data from sensors, processes it according to pre-written code, and sends signals to control various output devices. Wi-Fi Module: Enables Internet of Things (IoT) capabilities, allowing the system to send real-time data to a cloud platform or receive remote commands via a smartphone or web dashboard. PC with ML Software: Indicates that the system can be integrated with Machine Learning (ML) software. The PC likely analyze sensor data to predict needs (like when a plant will need water) and sends optimized instructions back to the Arduino. Temp/ Humid Sensor: Typically a sensor like the DHT11 or DHT22, it measures ambient air temperature and humidity. 2 x 16 LCD: A Liquid Crystal Display that shows real-time data such as current temperature, humidity levels, or the status of the pumps.

DC Power Supply: Provides the necessary voltage (usually 5V to 12V) to run the Arduino and the high-power components like pumps. The system controls three main environment adjusting modules through specialized drivers: Humidifier Driver & Pump: When humidity falls below a set threshold, the Arduino triggers this driver to turn on a humidifier or misting pump to increase air moisture.

Lamp Driver & Lamp: Used to control artificial lighting. This can be programmed to provide consistent “sunlight” or turned on/off based on light levels.

DC Pump Driver & DC Water Pump: This module manages irrigation. When sensors detect dry soil, the driver activates the water pump to deliver water directly to the plant’s roots. Drivers (like relays or MOSFETs) are necessary because pumps require more current than the Arduino pins can provide directly

## 6. WORKING

Shows the block diagram of Aeroponics system indoor farming. The proposed system block diagram illustrated above consists of an 8-bit microcontroller and a Wi-Fi enabled chip, thoughtfully selected for its UART for serial communication, ADC for analog parameter measurement, one wire protocol compatibility, and other essential features. The system utilizes various sensors to gather environmental data, which is then transmitted to the lot device. The lot device serves as an input source for the microcontroller, allowing for further data processing. The results are then displayed on an LCD screen, providing real- time readings of the sensor values. A moisture sensor, employing soil conductivity, measures the moisture levels, with the microcontroller converting the voltage to digital data. When the soil moisture falls below a specified. threshold, the water pump activates, and vice versa. A DHT11 digital temperature and humidity sensor is also incorporated to monitor the current environmental humidity and temperature. Additionally, an NPK sensor is utilized to monitor the levels of nitrogen (N), phosphorus (P), and potassium (K)in the soil. If the soil is found to be deficient in any of these nutrients, the respective NPK pump will be turned on or off accordingly. The microcontroller interfaces with the esp8266 Wi-Fi modem via serial communication, utilizing three wires for connection RX TX, and Ground. AT (attention) commands, such as AT-RST and AT+CIP, facilitate seamless communication between the Wi-Fi modem, microcontroller, and the lot cloud server. To visualize and monitor the collected data, a employed, displaying all relevant information on a virtual display.

## 7. RESULTS AND CONCLUSION

**Fig. Complete Working Model**

In conclusion, agriculture remains a vital sector for economic growth and food security, particularly in countries like India. The early detection of plant diseases is essential to safeguard crop yields and ensure sustainable farming practices. This project successfully demonstrates an integrated system combining convolutional neural networks for accurate disease classification with an automated pesticide spraying mechanism. By enabling early identification and prompt intervention, the system helps prevent disease spread and reduces manual labor and chemical usage. Overall, this approach contributes significantly to advancing precision agriculture, promoting healthier crops, and supporting sustainable food production through the effective use of AI and IoT technologies.

**Fig. Model**

## CONCLUSION

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