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Brief Editorial Overview: Inductive Research – Analytical Research Paper

Analysis of Internal Stress Distribution in Polycarbonate through Photoelastic Techniques

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Abstract: Recent advances in Internet of Things (IoT)-enabled hydroponic and aquaponic system research highlight a potentially transformative shift in agricultural paradigms. These cutting-edge solutions tackle a variety of issues, from the need for sustainable farming practices to extreme environmental circumstances. The attainment of increased growth rates and enhanced crop production through careful monitoring and management of environmental conditions is a recurring topic in all the research. Actuators, sensors, and microcontrollers can be integrated to optimize plant development and reduce human dependency by adjusting fertilizer delivery and ambient conditions in real-time. This integration is typically made possible by platforms like NodeMcu and Raspberry Pi. A workable approach for sustainable food production, the studies also highlight the use of these systems in areas were traditional farming faces significant obstacles. It is explored how hydroponics and aquaponics might help with precision agriculture in urban and suburban areas where farmland is scarce, in addition to alleviating the issue of food scarcity. The findings recommend ongoing research in the fields of data science, AI, and UI design in order to improve and enhance these technologically advanced farming methods. The convergence of cutting-edge technologies and environmentally conscious agricultural methods portends a future in which Internet of Things-enabled hydroponic and aquaponic systems are essential to guaranteeing food security worldwide.

Keywords: IoT, Web, WWW, Hydroponics, Framing, NedeMcu.

1. Introduction

The combination of cutting-edge technologies and creative farming methods has led to the development of a new area of study in recent years that focuses on the Internet of Things (IoT) integrated hydroponic and aquaponic systems. This intersection signifies a paradigm shift away from conventional farming toward increased productivity, sustainability, and accuracy. The soil-less growth technique known as hydroponics has become more popular because of its ability to maximize agricultural yields while minimizing environmental impact and resource usage. At the same time, a holistic method known as aquaponics a hybrid of hydroponics and aquaculture has gained popularity. It uses the mutualistic interaction between fish and plants to build a closed-loop, sustainable ecosystem.

Real-time monitoring and control of critical environmental factors is made possible by the integration of IoT technology into these systems, which has emerged as a research focus. Because of this connectedness, remote management is made easier and crops are given accurate and timely treatments for the best possible growth. Together, the research presented here highlights the many advantages of these intelligent farming systems, from resolving issues in challenging agricultural regions to satisfying the growing demand for food worldwide.

The framework for a thorough examination of current research projects that examine the development, application, and assessment of IoT-enhanced hydroponic and aquaponic systems is provided in this overview. These studies offer insights into the changing landscape of technology-driven sustainable farming methods as agriculture embraces the digital revolution.

2. Literature Review

Dr. Asawari Dudwadkar et al. (2020) conducted an investigation on a hydroponic system that ensures a controlled environment and an accelerated growth rate. To enhance the efficiency of plant and vegetable production, the system employs actuators to systematically monitor and regulate many parameters. The experiment

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demonstrates that well-managed hydroponic systems have higher growth rates and less reliance on physical effort.

Dr. Sudha Suresh et al. (2021) have undertaken a study to address the issue of crop production in places characterized by adverse environmental conditions, where conventional farming practices face significant challenges. The proposed solution entails the implementation of an automated hydroponic system, which has the potential to enhance food production. This approach use motorized pumps to autonomously administer fertilizers to plants while simultaneously monitoring crucial water conditions. The utilization of a microprocessor, specifically the Raspberry Pi, facilitates the establishment of a webpage that enables the remote supervision and administration of the entire system configuration. Hydroponics, a cultivation method that employs water as the growth medium, has demonstrated the capacity to generate greater crop yields within compressed timeframes. This technique presents a potential remedy for the difficulties encountered in agricultural practices inside inhospitable regions, while also promoting the progression of sustainable food production.

IoT was used in the design and execution of an autonomous smart hydroponics system by Ravi Lakshmanan et al. (2020). The idea of sustainability aims to tackle the issues brought about by the rising demand for food and the requirement for a sustainable agricultural method. The system transmits data to the cloud and oversees and regulates the hydroponic environment through the utilization of NodeMcu, Node Red, MQTT, and various sensors. The study also introduces a bot designed for supply chain management and alerting purposes. A performance evaluation of the system is carried out with an emphasis on hydroponics and the IoT. The study provides recommendations for additional exploration in the fields of data science, artificial intelligence (AI), and user interface (UI) design in order to better the system.

Hydroponics, as posited by Garcia et al. (2022), is a technique used in agricultural that operates in absence of soil, presenting a viable alternative for mitigating the challenge of limited food availability. The difficulties in putting this strategy into practice on a small scale, as well as the related technological elements. Furthermore, the authors emphasize the significant role of hydroponics in addressing the food demand, specifically in urban and suburban regions characterized by limited availability of arable land. The utilization of small-scale hydroponic production and resource conservation can be enhanced by the implementation of precision agriculture techniques, facilitated by the integration of concepts like as Industry 4.0 and the IoT.

In their study, Mahkeswaran et al. (2020) developed an intelligent and environmentally friendly residential aquaponics system that incorporates IoT technology for the purpose of monitoring and regulating various factors. The system comprises a range of sensors, actuators, and microcontrollers that are equipped with internet connectivity. These components work together to provide ongoing monitoring, control, and recording of both the water quality within the fish tank and the ambient air quality. The technology effectively promotes the well-being of fish and plants by promptly notifying the user of any irregularities in the system through a push notification in a comprehensive IoT smartphone application.

In their study, R. Ahmad et al. (2020) undertake a comprehensive analysis to examine the current state and global developments of aquaponics systems, with a particular focus on intelligent and IoT technologies, as well as crucial sensing variables. In order to develop a viable commercial aquaponics solution, the study also looks at and offers a thorough analysis of the different aspects related to aquaponics. Furthermore, it conducts an in-depth examination of the Internet of Things and innovative technologies that have been documented in earlier studies. Regarding automated aquaponics systems, this discussion aims to elucidate the prospective advancements that can be anticipated in this field, while also identifying potential gaps in the existing body of scholarly work.

A comparative analysis of aquaponic and hydroponic farming was conducted by Rachida Ait et al. in the year 2021. The study aimed to provide a detailed overview of both methodologies. Aquaponic farming involves the integration of hydroponic techniques with aquaculture, which pertains to the production of fish, whereas hydroponic farming refers to the practice of growing plants in absence of soil. The hydroponics technique offers advantages even in challenging environmental circumstances such as extreme heat, cold, and desert environments. The impact of climate change on the system is negligible, as it exhibits a very stable pattern throughout the year.

Shewale et al. (2018) propose a cost-effective solution based on the IoT for the purpose of remotely monitoring and automating hydroponic farming. The system utilizes sensors to assess the pH, temperature, and electrical conductivity of the nutritious solution, with the collected data then transmitted to a Raspberry Pi microcontroller. Subsequently, the microprocessor assumes control over the operation of the pumps and valves in order to maintain the solution to optimal levels for plants. Moreover, system presents the data to the user through a web-based application and transfers it to a cloud server.

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In their study, R. Rajkumar et al. (2018) conducted research on a hydroponic farming method that utilizes artificial nutrients, water, and IoT to cultivate plants in absence of soil and sunlight. The study provides a description of a system that utilizes a smartphone application for the purpose of remotely monitoring and managing environmental conditions and plant growth. The research paper also outlines the many hardware and software components that are vital to the functioning of this system.

Syarif et al. (2018) describe a hydroponic system that combines a smartphone with Android OS and the Arduino Uno microprocessor. The system is designed to automate the regulation of nutrient solution flow, as well as monitor the water level and temperature. In order to attain automation, the system utilizes ultrasonic, temperature, and water level sensors, a WIFI module, a relay, and a pump.

Partha Pratim Ray et al. (2017) looked into the advantages and disadvantages of using Internet of Things, or IoT, software in the farming and agricultural sectors. This study examines the hardware components, communication methodologies, and sensor-based systems that provide intelligent services to enhance agricultural practices. Furthermore, the text elucidates a multitude of case studies, obstacles, and prospective advancements pertaining to IoT enabled agricultural solutions.

The visualization technique employed by SK Ahammad Fahad et al. (2018) utilizes Python and R programming languages. The methodology outlines the process of visualizing large datasets for the purpose of real-time recognition, employing practical decision-making techniques through the utilization of graphical user interface (GUI) tools. The visualization techniques in R and Python. R comes equipped with a range of powerful visualization libraries, including ggplot2, leaflet, and lattice, which effectively address the issue of handling enormous datasets. This study aims to demonstrate the extensive range of visualization alternatives available for big data by doing a comprehensive meta-analysis. The investigation will involve mapping the variances in tools utilized for big data visualization and conducting a comparative assessment of the existing tools. The offered material will facilitate developers in acquiring knowledge regarding the factors and optimal approaches for initiating novel services catering to both professionals and general consumers.

B. Martin-Gorriz et al. (2021) conducted an environmental footprint analysis on hydroponic tomato production that utilized photovoltaic solar energy and reverse osmosis. This study set out to determine whether it would be feasible to use reclaimed drainage waste water for hydroponic tomato farming. According to the findings, the proposed system exhibited a reduced environmental footprint in comparison to conventional hydroponic systems. The research highlights the potential advantages of incorporating renewable energy sources and recovered drainage pollutants in hydroponic growing practices.

The study conducted by Nikita Bakhtar et al. (2018) investigates the hydroponic system that utilizes IoT technology to monitor and adjust several variables. The utilization of this technology circumvents the costs associated with manual labor and the need for plowing, while also being unaffected by weather conditions. The designated individual has the capability to remotely monitor the ongoing development of the plant in real-time. This work presents a novel approach to creating a resource-efficient and adaptive cultivation environment for nutrient-rich crops.

In their study, Freeman et al. (2022) used a comparative analysis to examine the differences between hydroponic controlled-environment agriculture and field-based supply chains in relation to lettuce production. The findings of the study indicated that hydroponic controlled-environment agriculture exhibited reduced carbon footprint, water footprint, and land consumption in comparison to field-based supply chains. This study emphasizes the promise of hydroponic controlled-environment agriculture as a viable and sustainable alternative to traditional farming practices.

Matthew Gentry et al. (2019) in Sweden examined the potential advantages of integrating district heating (DH) with vertical hydroponic farming (VHF). In contrast to conventional farming practices, vertical hydroponic farming (VHF) offers several advantages, such as enhanced efficiency in land and water utilization, as well as reduced transportation costs, particularly when implemented inside urban settings. To adhere to the stipulations of 4th Generation District Heating (4GDH) standards and mitigate carbon dioxide (CO_2) emissions within the food and energy production sectors, the integration of Variable Heat Flow (VHF) devices is implemented inside District Heating (DH) systems with the objective of reducing the temperature of the return flow.

The design and planning of solar-assisted hydroponic farms (SAHFs) can be impacted by photovoltaic (PV) system subsidy programs, according to a recent study by Al-Ansari et al. (2022). The efficiency of the subsidies is taken into consideration, although the evaluation primarily focuses on the financial gains and production results of SAHFs. The increased electricity tariff (IET), investment co-funding (ICF), and feed-in tariff (FIT) are the subsidy mechanisms being considered. To increase the type and capacity of the photovoltaic (PV) system simultaneously, a

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quadratic programming model is developed.

The study conducted by S. Siyang et al. (2018) investigates a sophisticated hydroponic system that utilizes IoT technology to effectively control several factors including as light intensity, water level, temperature, and humidity. The efficacy of the system in facilitating real-time data archiving for end users was demonstrated. Plants subjected to blue supplemental LED light exhibited increased biomass, leaf density, leaf area, and pigment content. The objective of the research was to propose a sustainable and enduring resolution for addressing food security and production within a societal context characterized by escalating rates of obesity.

Harsha A et al. (2018) describe a novel methodology for soilless cultivation, including hydroponics and IoT technologies. This paper elucidates the functionalities of the NodeMCU and Adafruit.io platforms in the measurement and regulation of diverse parameters, including temperature, humidity, pH, and nutrition. This study showcases the utilization of Google Assistant in the context of remote system monitoring and control.

In order to automate hydroponic farming, Sahar Khan et al. (2018) give a thorough explanation of the creation and implementation of an IoT system. The system uses sensors, actuators, and a microcontroller to monitor and regulate environmental factors like pH, temperature, humidity, and electrical conductivity of the growing medium. In order to enable data storage, display, and remote user control, the system connects to a cloud server and a mobile application.

Lakshmanan et al. (2019) introduce a smart classroom system that utilizes beacons and mobile devices for interactive purposes. The system has the capability to provide students with personalized learning materials, evaluations, and feedback based on their location and individual preferences. The system has the ability to track the children's attendance, engagement level, and academic success by means of data analytics.

In their 2017 study, Prasad et al. suggest a solar-powered system that enables the remote administration and automation of agricultural operations through the utilization of wireless sensors and the IoT. The system comprises of a Raspberry Pi controller, a data logger, a server, an application, and a user device. By employing wireless sensors, the system controls the progress of crop development, the level of soil moisture, and the extent of crop damage. Subsequently, the data can be transmitted to the user's device via the internet. The software program enables the user to further control the fertilization and irrigation of the crops.

In their study, Rajeswari Aravind et al. (2018) conducted an analysis of the concept and benefits associated with hydroponics, a method of agriculture that involves the cultivation of plants without the use of soil, utilizing water and nutrient solutions instead. This paper elucidates the advantages and challenges associated with hydroponics in the context of India, encompassing aspects such as pest management, crop diversification, land availability, and water scarcity. Hydroponics, due to its ability to establish a controlled environment that effectively hinders the occurrence of insect infestation and transmission of diseases, has the potential to mitigate the reliance on pesticides.

Adam Zaheer et al. (2018) comprehensively address the potentialities and challenges with the implementation of IoT applications in the domain of farming and agriculture. This study investigates the various tools, networks, and sensor-enabled systems that provide intelligent services aimed at enhancing agricultural productivity. Additionally, this study encompasses a variety of case studies, obstacles, and prospective advancements pertaining to IoT applications in agriculture field.

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3. Result and Discussion

As various academics have investigated, the integration of IoT with hydroponic systems has produced encouraging results and conversations that highlight the revolutionary potential of these cutting-edge methods in agriculture. The effectiveness of a monitored hydroponic system is demonstrated by Dr. Asawari Dudwadkar et al. (2020), who reveal a higher growth rate and less reliance for human intervention.

This emphasizes how the production of plants and vegetables is greatly impacted by regulated environments, made possible by the Internet of Things.Dr. Sudha Suresh and colleagues (2021) highlight the difficulties associated with conventional farming in arid areas and propose the use of an automated hydroponic system, citing its potential to increase food production. This strategy, which promises higher yields in shorter amounts of time, stands out as a sustainable one because it makes use of motor pumps and ongoing water parameter monitoring.

Global issues about food demand and sustainability are addressed by Ravi Lakshmanan et al.'s (2020) investigation of an automated smart hydroponics system utilizing IoT technologies. In order to maximize system performance, presents cloud-based monitoring using NodeMcu, Node Red, MQTT, and sensors. It also makes recommendations for additional data science, artificial intelligence, and UI design.

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The significance of hydroponics as a soilless farming technique is highlighted by Adrian L. Garcia et al. (2022), especially in metropolitan areas with limited cropland. The authors highlight how Industry 4.0 ideas might be used to precision agriculture made possible by IoT to promote resource efficiency and small-scale hydroponic farming. These investigations demonstrate the benefits and revolutionary possibilities of combining Internet of Things technology with hydroponic and aquaponic systems. The approaches being considered to open the door to efficient and sustainable farming methods in the future, from increased yields and controlled conditions to resolving difficulties in various agricultural settings.

4. Conclusion

Combining IoT technologies with hydroponic and aquaponic systems shows promise as a revolutionary way to tackle a variety of agricultural issues. Taken as a whole, the findings highlight how these novel systems might help alleviate problems like food scarcity, extreme weather, and the need for sustainable farming methods. The study highlights the benefits of regulated settings made possible by IoT, which lead to faster growth rates, less reliance on humans, and more food output. The studies also emphasize how crucial precision agriculture is for advancing small-scale hydroponic production and resource conservation. Precision agriculture is made possible by concepts like Industry 4.0 and the Internet of Things. Overall, these findings open the door to a future in which technology-driven agricultural practices are critical to maintaining global food security by supporting continued research into data science, artificial intelligence, and user interface design.

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