IoT-Based AI Controller and Mobile App for Solar-Smart Hydroponics

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Abstract. Hydroponic agriculture utilises far less water and other resources than soil-based production. Due to the many variables, plant nutrients, and diagnostic methods, hydroponics cultivation is tough to monitor. Recent technical advances have helped find answers by enabling the use of AI-based control algorithms in agriculture. This project aims to create a smartphone app that talks with an AI-based intelligent hydroponics system. The IoT-enabled intelligent hydroponic system has three phases. The hardware environment includes real-time sensors for NPK soil, sunshine, turbidity, pH, temperature, water level, and a camera module in the first stage. A Deep Learning model will predict nutrient concentrations and categorise plant illnesses in the second phase. An Android-based Internet of Things smartphone software lets farmers track sensor data and leaf diseases in the final phase. The farmer may also monitor his land using the software. This system also automates hydroponics maintenance to enhance production.

Keywords: Smart Hydroponics · AI-Based Controlling · Deep learning · Nutrient Level Prediction · Plant Diseases

1 Introduction

IoT might transform agriculture, affecting people and the planet [1]. Food production is getting harder and more costly due to weather extremes, soil erosion, drought, and ecosystem destruction. Each component contributes. No price reductions since then. By 2050, the global population will exceed 9 billion. Technology and the internet of things for intelligent agriculture seem promising, though [2]. These two elements improve future prospects. According to the researchers, the hydroponic systems market will be valued $23.14 billion by 2023, and 75 million Internet of Things-connected devices will be used in agriculture. The Internet of Things allows remote sensing and control of physical things, enabling a more seamless link between the real world and computer systems. The Internet of Things connects sensors-equipped devices [3, 4]. Ethiopia and India rely on agriculture for food. Even though traditional agriculture might profit from higher crop yields, several challenges must be solved first. Rural areas face global climate change, pollution, soil degradation, urbanisation, and the loss of agricultural land.

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Producing more food requires sustainable agriculture [5, 6]. Innovative and time-tested farming practises will need professional leadership to reduce global food shortages. Hydroponics, vertical growing, and polyhouses will help overcome these challenges. Today's technological needs make hydroponics the most productive kind of agriculture [8].

2 Problem Statement

Modern hydroponics systems may have nutrient delivery concerns, seedling issues including wilting and root death, system obstructions, parasites like algae and insects, and system barriers [7]. Seedling growth is hydroponic plant cultivation's hardest problem. This may hinder. Seedlings have early issues. Baby seedlings. Wilting weakens and dehydrates leaves. causes wilting. Poor hydration and high heat wilt plants [8]. Underwatering and excessive humidity promote withering [8]. Withering has several causes. Roots may perish from excessive water temperature, soil electrical conductivity, or overwatering on thick substrates. This may occur with high or low soil electrical conductivity. A system with dead roots may have a root rot fungus. System breach. Trickle irrigation systems especially. Hydroponics agrees. Growth media blocks most tubes. Vessels hold these particles. Blockages may harm plants by restricting water flow. Barriers impede water movement. Assess the nutritional solution's electrical conductivity, water flow, temperature, and pH before diagnosing [9]. Before diagnosing, do these steps. Hydroponics need self-driving robots with industrial robotics and hardware controllers to develop plant spores. Consumer robots require industrial robots. Their inability to monitor several sensors made it tougher to address the issues in the preceding paragraph. Conventional and hydroponic plant diseases limit agricultural output. These substances cause unusual plant growth. Farmers diagnose illnesses with their bodies, whereas pathologists use scientific techniques. Conventional methods require time and rely on the worker. Early plant disease identification and control may improve hydroponics efficiency [10–13].

3 Objective

A. Design and implementation of user-friendly environment for farmers using Agri-Hydroponic application, which provides hybrid monitoring and controlling of hydroponics farm field.
B. Implementation of AI framework for predictive analysis of sensor data and alerting the end users (farmers).

4 Literature Review

"Sustainable development in agriculture: the historical and present situation of In-dian agriculture," by V. Bhatnagar and associates [14] finishes. Sustainable agriculture: India's history and present was the study's title [14]. Sustainable Agriculture: Indian Agriculture's History and Present was the research project [14, 15]. This report was titled

"Sustainable Development in Agriculture: The History and Present Situation of Indian Agriculture" [15]. The authors' IoT is based on the Internet of Everything (IoE), a popular foundation for IoT development. IoT is this basis. IoE underpins the authors' IoT. IoT underpins IoE. Advanced soil sensors increase crop monitoring in agricultural regions. Improve crop monitoring overall. The recommended technique would save electricity but reduce crop growth monitoring component heat index accuracy. These components check crop health. The suggested method saves more energy. N. G. Rezk and partners' irrigation method would use less energy [16]. "An efficient IoT-based smart agricultural system employing machine learning algorithms," South Africa will introduce completely autonomous water management in 2021 to prevent water wastage. Save water. This protects local environment [18]. The IoT powers a highly productive machine learning-based intelligent farming system. Assessing the ground and water supplies completes the process. Technology minimises parameter current and increases data transmission range. Maintaining performance. Z. Khan, S. Ali, and colleagues calculated wheat harvest nitrogen concentration in a second study [17]. Z. Khan, S. Ali, and colleagues authored this. The research was titled "Internet of things-based smart farming monitoring system for bolting reduction in onion fields". This word fit the investigation's topic. "Internet of things-based smart farming monitoring system for bolting reduction in onion fields" is the study's title. Crop pictures collected in real time under different illumination and time intervals provided the estimated data. This analysis provided data. P. S. Chatterjee and colleagues [19] created an intelligent agricultural technology system employing decision tree classification. AI-powered IoT system. AI predicts agricultural attributes using hardware data. Due to environmental energy constraints, this technology may produce real-time supply issues. Limits may cause complications. I. L. Maldonado and colleagues [20] designed a hydroponic automated system to assess plant development from seedling to harvest. This found ideal plant growth circumstances. In many applications, the ESP32 microcontroller controls actuators and sensors. It's versatile. Thus, microcontrollers are versatile. The LOTUS mobile app now tracks temperature, humidity, and irrigation. If we employ this strategy, we'll have to perform more computer work if we're late. The authors [4] created a hybrid method to monitor many parameters. pH, nutritional content, and water temperature. Regional characteristics vary. Based on the nutrient film technique's reference water levels, KNN automates these alterations. This enables smooth operation. Deep learning is more reliable and efficient.

5 Proposed Methodology

Smartphone app, Raspberry Pi computer, and IoT environment power this hydroponic farming system. Farms are managed manually and automatically. Programmes alter modes. Software supports any mode. Raspberry Pi sensors feed an Internet of Things cloud. This ecosystem processes data. Cloud sites build deep learning-based AI systems. It's distributed computing. Sensor data and plant disease alert farmers. Hydroponics grower. This feeds the grower's plants. Still crucial. Automated systems fertilise by reference. It feeds plants. Automated this (Figs. 1, 2).

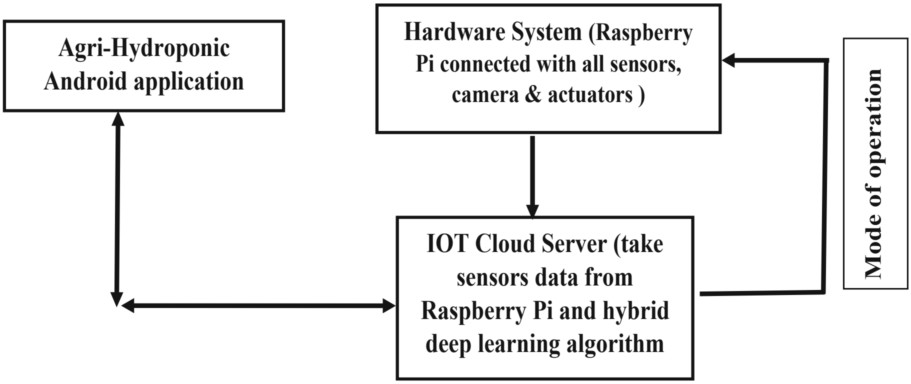

Fig. 1. Proposed system architecture

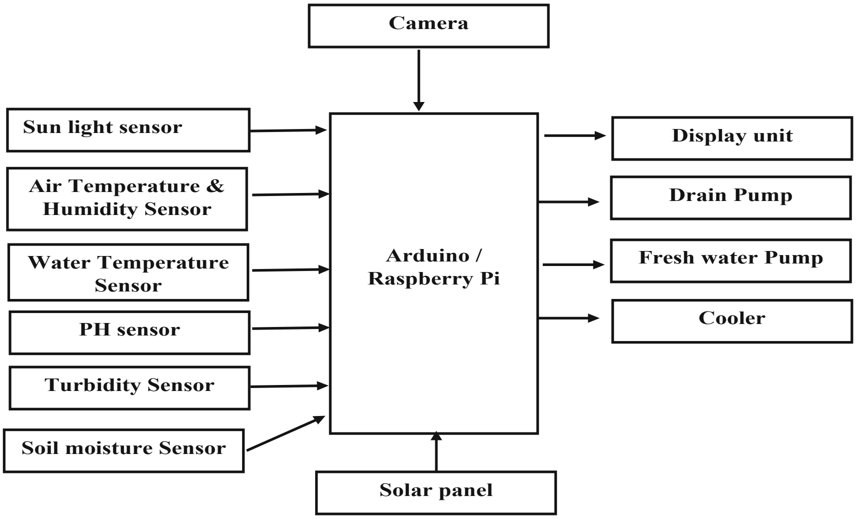

Fig. 2. Proposed system hardware Section

Raspberry Pis operated sensors. Sensors track hydroponics. It regulates drinking water temperature, water level, sunshine, sewage disposal, cooling, and more. Nutrient-rich freshwater. IoT cloud sensors update data. Consumers always know better. It mimics sunshine. Grove sensors sense sunlight. Leaf photosynthesis. Environmental research requires SHT-20 sensors. Hydroponics requires real-time water mineral monitoring. Water feeds. Water alone nourishes. Hydroponic gear requires more water sensors than usual. Impermeable probes measure water temperature. PH sensors measure turbidity.

Cloudy water. NPK sensors detect liquid nitrogen, phosphate, and potassium, not soil moisture.

It's flexible. NPK sensors gain. Pressure sensors. Cameras record plant frequency.Raspberry Pi sends Deep Learning cloud servers sensor data and images. Prediction-Deep Learning compares current nutrient levels to reference values to identify plant shortages. Dietary needs. Averages nutrition. Early identification is critical since nutrient shortages cause plant diseases. Epidemics necessitate early identification. Photo classification-Deep Learning neural networks detect plant diseases. AI does. Agri-Hydroponic models. Growers choose. Hydroponic farmers check nutrients. Deep neural networks teach Raspberry Pi controllers. Controllers choose outputs. Controls production. Pumps, motors. Watered and fed. Plants get mineral-rich water. Hydroponics heaters control air and water temperatures. Thermostats improve. Battery-charging panels.

Deep learning models must classify and predict. Predictions kind. Cloud storage makes these models accessible. Deep learning networks predict nutritional values from reference values. Teaching again. Deep learning detects plant diseases. Yield grows. Categorization-based deep learning created the farmer's mobile app's input feature matrix using sensor data. Learning increases. Analysed hydroponic sensor data. Raspberry Pis examine cloud data.Sensors and algorithms predict deep learning. Sensors predict. Deep learning estimates sensor nutrient levels using the reference dataset. The trained model permitted this. Sensor data and ambient circumstances change, thus prediction-based deep learning can determine nutritional levels. Could be.

6 Results

We'll examine the system's implications on the internet of things in this part. Discussing the system caused these results. The suggested models are also compared to state-of-the-art deep learning prediction and classification methods using standard nutrition and plant leaf datasets. This comparison assesses the offered models' accuracy. This comparison evaluates model precision. To accurately evaluate the models presented, this is done. One reason for this is to ensure an accurate assessment of the given models (Fig. 3).

Figure 4: Deep learning networks identify plant diseases. Classified items. Classifies illnesses. Model here. The outcomes. Deep learning produced Table 1. It uses three sensor kinds. Summer, winter, and summer samples. Sensors predicted nutritional needs. Sensing physiology. Sensor data and organism physiology enabled this. Table 2 displays findings. Classified illnesses. Method worked. Classifying illnesses aided treatment. It outperforms K-nearest neighbour, ANN-Genetic algorithm, and Hybrid-CNN. The method improves cutting-edge solutions. Results improved. K-nearest neighbour, ANN-Genetic algorithm, and Hybrid-CNN data processing. Several methods accomplished goals.

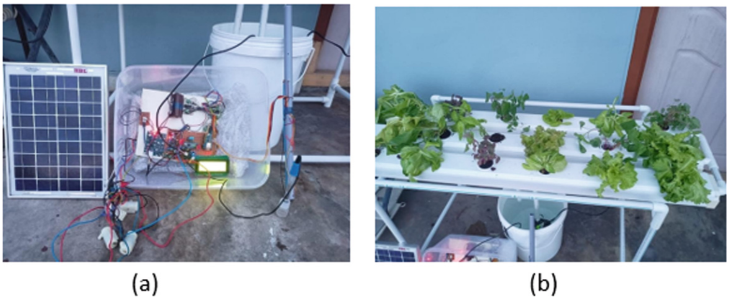

Fig. 3. Complete Hardware Setup

Table 1. Performance estimation of Prediction Deep learning models

Method	Accuracy (in %)	Recall (in %)	Precision (in %)	F-measure
EFIS	89.8	90.51	89.52	90.66
Support Vector Machine	92.8	93.11	89.11	90.234
Mic-Conv Net	93.26	94.52	91.88	92.69
R-CNN	94.21	95.34	92.66	94.67
Prediction based deep learning	98.23	97.554	98.12	97.68

Table 2. Performance estimation of Classification deep learning models

Method	Accuracy (in %)	Recall (in %)	Precision (in %)	F-measure
K—nearest Neighbour	87.45	83.02	86.77	82.34
ANN—Genetic Algorithm	89.04	91.88	89.35	90.11
Hybrid CNN	91.78	93.478	89.10	91.078
Classification based deep learning—CNN	96.78	97.67	97.12	97.5

7 Conclusion

This article describes how AI and the IoT created a hydroponics system. Authors built the system. Integrating a mobile app with Raspberry Pi's IoT environment is needed. The book analyses this practice's repercussions. Hydroponic farmers may adjust their fields using Agri-Hydroponic software. Hydroponic farm sensors are read by a Raspberry Pi-controlled gadget. This maximised harvest. IoT cloud services receive sensor data. Deep learning powers AI and machine learning. Cloud construction. This device monitors plant health, interprets sensor data, and informs farmers via mobile app about disease outbreaks. The farmer shifted from automated to manual hydroponics to ensure

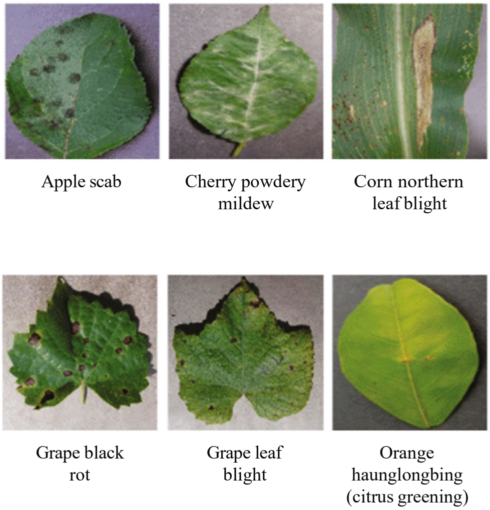

Fig. 4. Classification of Diseases in plant using classification based deep learning

plant nourishment. Plant nutrients are given automatically at predetermined amounts. Whether manual or automatic. System running. Optimisation and hybrid deep learning architectures may boost this system's performance.

References

1. W. Tao, L. Zhao, G. Wang, and R. Liang, "Review of the internet of things communication technologies in smart agriculture and challenges," Computers and Electronics in Agriculture, vol. 189, article 106352, 2021.
2. S. Qazi, B. A. Khawaja, and Q. U. Farooq, "IoT-equipped and AI-enabled next generation smart agriculture: a critical review, current challenges and future trends," IEEE Access, vol. 10, pp. 21219–21235, 2022.
3. D. Das, J. Sahoo, M. B. Raza, M. Barman, and R. Das, "Ongoing soil potassium depletion under intensive cropping in India and probable mitigation strategies. A review," Agronomy for Sustainable Development, vol. 42, no. 1, pp. 1–26, 2022.
4. M. O. H. D. B. K. Putra and N. Nopriadi, "IOT based SMART agriculture using fuzzy logic," Computer and Science Industrial Engineering (COMASIE), vol. 6, no. 2, pp. 52–61, 2022.
5. K. Lova Raju and V. Vijayaraghavan, "A self-powered, realtime, NRF24L01 IoT-based cloud-enabled service for smart agriculture decision-making system," Wireless Personal Communications, pp. 1–30, 2022.
6. E. S. Mohameda, A. A. Belal, S. K. Abd-Elmabod, M. A. El-Shirbeny, A. Gad, and M. B. Zahrana, "Smart farming for improving agricultural management," The Egyptian Journal of Remote Sensing and Space Science, vol. 24, no. 3, pp. 971–981, 2021.
7. E. Nigussie, T. Olwal, G. Musumba, T. Tegegne, A. Lemma, and F. Mekuria, "IoT-based irrigation management for smallholder farmers in rural sub-Saharan Africa," Procedia Computer Science.
8. A. Sharma, M. Georgi, M. Tregubenko, A. Tselykh, and A. Tselykh, "Enabling smart agriculture by implementing artificial intelligence and embedded sensing," Computers & Industrial Engineering, vol. 165, article 107936, 2022.

9. M. E. Karar, A. H. Abdel-Aty, F. Algarni, M. F. Hassan, M. A. Abdou, and O. Reyad, "Smart IoT-based system for detecting RPW larvae in date palms using mixed depthwise convolutional networks," Alexandria Engineering Journal, vol. 61, no. 7, pp. 5309–5319, 2022.
10. H. Pang, Z. Zheng, T. Zhen, and A. Sharma, "Smart Farming," International Journal of Agricultural and Environmental Information Systems (IJAEIS), vol. 12, no. 1, pp. 55–67, 2021.
11. A. Khan, U. Nawaz, A. Ulhaq, and R. W. Robinson, "Real-time plant health assessment via implementing cloud-based scalable transfer learning on AWS DeepLens," PLoS One, vol. 15, no. 12, p. e0243243.
12. F. Sabrina, S. Sohail, F. Farid, S. Jahan, F. Ahamed, and S. Gordon, "An interpretable artificial intelligence based smart agriculture system," Computers, Materials & Continua, vol. 72, no. 2, pp. 3777–3797, 2022.
13. D. Adidrana, A. R. Iskandar, A. Nurhayati et al., "Simultaneous hydroponic nutrient control automation system based on Internet of Things," JOIV: International Journal on Informatics Visualization, vol. 6, no. 1, pp. 124–129, 2022.
14. V. Bhatnagar and R. C. Poonia, """sustainable development in agriculture: past and present scenario of Indian agriculture." research anthology on strategies for achieving agricultural sustainability," IGI Global, pp. 1342–1364, 2022.
15. N. G. Rezk, E. E.-D. Hemdan, A.-F. Attia, A. El-Sayed, and M. A. El-Rashidy, "An efficient IoT based smart farming system using machine learning algorithms," Multimedia Tools and Applications, vol. 80, no. 1, pp. 773–797, 2021.
16. P. Wang, B. A. Hafshejani, and D. Wang, "An improved multilayer perceptron approach for detecting sugarcane yield production in IoT based smart agriculture," Microprocessors and Microsystems, vol. 82, article 103822, 2021.
17. Z. Khan, M. Zahid Khan, S. Ali et al., "Internet of things-based smart farming monitoring system for bolting reduction in onion farms," Scientific Programming, vol. 2021, 15 pages, 2021.
18. J. Arshad, M. Aziz, A. A. Al-Huqail et al., "Implementation of a LoRaWAN based smart agriculture decision support system for optimum crop yield," Sustainability, vol. 14, no. 2, p. 827, 2022.
19. P. S. Chatterjee, N. K. Ray, and S. P. Mohanty, "LiveCare: an IoT-based healthcare framework for livestock in smart agriculture," IEEE Transactions on Consumer Electronics, vol. 67, no. 4, pp. 257–265, 2021.
20. I. L. Maldonado, J. M. M. Reyes, H. F. Breceda, H. R. Fuentes, J. A. V. Contreras, and U. L. Maldonado, "Automation and Robotics Used in Hydroponic System," in Urban Horticulture-Necessity of the Future, Open, London, United Kingdom, 2019.