Intelligent Aeroponics System Using Machine Learning

Karthik M Naik[1], Mohammed Hisham[2], Mohammed Muzain[3], Omkar Basavaraj Yelde[4], Shivaprasad T K[5]

[1]*Dept OF CS&E, MITE, Moodabidri, Mangalore*
[2] *Dept OF CS&E, MITE, Moodabidri, Mangalore*
[3] *Dept OF CS&E, MITE, Moodabidri, Mangalore*
[4] *Dept OF CS&E, MITE, Moodabidri, Mangalore*
[5]Assistant Professor, *Dept OF CS&E, MITE, Moodabidri, Mangalore*

---***---

Abstract - The Intelligent Aeroponics System Using Machine Learning is a cutting-edge agricultural technology that leverages the power of artificial intelligence to enhance the cultivation of plants in a soilless environment. This system integrates an array of sensors to collect data on crucial environmental parameters, plant health, and growth conditions. A machine learning model, trained on historical data, analyzes this information to make informed decisions in real-time. The system employs data- driven algorithms to optimize the delivery of nutrients, misting intervals, lighting conditions, and environmental control parameters. It includes a user-friendly interface for remote monitoring and control, enabling users to receive timely alerts and notifications about the system's status. Additionally, computer vision-based models are used to detect early signs of pests and diseases, allowing for swift intervention. With an emphasis on energy efficiency, security, and scalability, this intelligent aeroponics system offers a sustainable approach to crop cultivation. Its continuous feedback loop and data analysis ensure crop optimization and resource conservation. The system can be adapted to various plant types and growth stages, making it a valuable tool for modern agriculture. Overall, the Intelligent Aeroponics System Using Machine Learning not only maximizes crop yields but also minimizes resource consumption, enhancing the efficiency and sustainability of agricultural practices.

Keywords: aeroponic, monitoring system, automatedsystem, Arduino, IoT, machine learning, lettuce.

1. INTRODUCTION

Agriculture is one of the most important productive sectors and sources of food, especially for developing countries; however, the increment of the population density generates that agricultural lands are limited. In Ecuador, the population growth rate is 1.8%, reaching in the last decade, approximately 17.48 million inhabitants. Therefore, greater areas of land intended for agriculture to satisfy food needs are required; nevertheless, the land-use dedicated to permanent crops in the country shows a decrease of 0.60% between 2016 - 2017. Furthermore, climate change, the indiscriminate use of soil, water, and the advancement of deforestation increasingly lead to the degradation of ecosystems. In this sense, alternatives for an environmentally friendly farming system are sought, such as aeroponics, hydroponics, aquaponics, etc. Aeroponics is a soil-less method of growing plants, where the roots are suspended in the air and sprayed with a nutrient-rich mist. Aeroponics has many advantages over traditional agriculture, such as saving water, space, and energy, reducing pests and diseases, and increasing crop yield and quality. However, aeroponics also requires precise control and monitoring of various environmental factors, such as temperature, humidity, pH, electrical conductivity, and nutrient concentration. This is where machine learning (ML) models can help.. ML models can also be used to optimize the performance of aeroponics systems, by adjusting the parameters of the misting system, such as frequency, duration, and droplet size, based on the feedback from the sensors and the desired outcomes. ML models can also provide insights into the growth and health of the plants, by analyzing the images or videos captured by cameras or drones.

In order to take advantage of resources and optimize agricultural production, it is necessary to implement innovative methods for integrating monitoring and control systems, to obtain accessible, immediate, and available information on the state of the culture, focused on preventing economic and crop losses. This concept involves the use of technologies, such as automated systems and communication interfaces. An automated system in agricultural processes, not only allows proper monitoring of the crops, but also with the inclusion of other tools, as the Internet of Things (IoT), the variable data can be collected and used in subsequent studies to improve crop growth and optimize important factors in productive development.

2. FEATURES

An intelligent aeroponics system using machine learning (ML) can offer several advanced features that enhance plant growth, optimize resource utilization, and improve overall system efficiency. Here are some key features:

Automated Monitoring and Control: ML algorithms can continuously monitor various parameters such as nutrient levels, humidity, temperature, and pH levels in the aeroponic system.

Predictive Analytics for Plant Health: ML models can analyze data from sensors and cameras to detect early signs of plant diseases, nutrient deficiencies, or pest infestations.

Optimized Nutrient Delivery: ML algorithms can analyze plant growth data and nutrient uptake patterns to optimize the delivery of nutrients through the aeroponic system.

Energy-Efficient Operation : ML can optimize energy usage in the aeroponic system by scheduling tasks such as lighting, ventilation, and nutrient delivery based on real-time data and environmental conditions.

Adaptive Learning and Optimization: Over time, the ML algorithms can learn from data collected during various growing cycles and continuously optimize parameters to improve crop yield, quality, and resource efficiency. This adaptive learning capability is crucial for long-term performance enhancement.

Remote Monitoring and Control: Through connected devices and IoT integration, an intelligent aeroponics system can be monitored and controlled remotely. This allows growers to access real-time data, receive alerts, and make adjustments from anywhere, enhancing convenience and flexibility.

Data-Driven Decision Making: ML algorithms enable data- driven decision-making processes by providing insights into plant growth trends, environmental conditions, and system performance. Growers can use this information to make informed decisions about crop management strategies and resource allocation.

Customized Growing Profiles: ML can create customized growing profiles for different plant varieties based on their specific requirements.

3. LITERATURE REVIEW

This section talks about previous studies conducted in the same field and their outcomes. The following are some of the references for the existing system .

In the paper "Automated aeroponics vegetable growing system. Case study Lettuce," 2020 IEEE ANDESCON, Quito, Ecuador, 2020, pp. 1-6, doi: 10.1109/ANDESCON50619.2020.9272180:

L. Lucero, D. Lucero, E. Ormeno-Mejia and G. Collaguazo , Develop automated aeroponic system using Arduino and IoT. Integrate sensors for real-time data, LCD display, relays, GSM GPRS shield, and water pump. Use GPRS for remote monitoring through ThingSpeak. Aeroponic culture outperformstraditional in leaf and root growth, plant density, and water management. Integration of IoT for remote monitoring is effective.

Another study, “A smart aeroponic tailored for IoT vertical agriculture using network connected modular environmental chambers,” 2018 IEEE 10th Int. Conf. Humanoid, Nanotechnology, Inf. Technol. Commun.Control. Environ. Manag. HNICEM 2018, pp. 4–7, 2019, doi:10.1109/HNICEM.2018.8666382: F. C. L. Belista, M. P. C.

Go, L. L. Lucenara, C. J. G. Policarpio, X. J. M. Tan, and R. G. Baldovino, This is aims to design a scalable IoT-enabled farming system for vertical agriculture. It focuses on connecting components, users, and the cloud to monitor and control factors crucial for crop growth.

The paper “Monitoring and control of aeroponic growing system for potato production,” Proc. 2012 IEEE Conf. Control. Syst. Ind. Informatics, ICCSII 2012, pp. 120–125, 2012, doi: 10.1109/CCSII.2012.6470485 : I. Idris and M. I. Sani,

Researchers have developed an aeroponic system for potato production, which has the potential to outperform conventional methods, especially in seed production followed by potato seed cultivation in the fields .

4. METHODOLOGY

This section describes the study area and proposes an intelligent and manageable architecture for a lettuce aeroponic culture, using an Arduino microcontroller and electronic devices to integrate the monitoring and control systems.

A. Monitoring and control system:

The electronic system carries out the programmed actions for the crop automated operation. It has been designed with different components that allow monitoring and manipulating the system variables to improve production performance, either on-site or remotely.

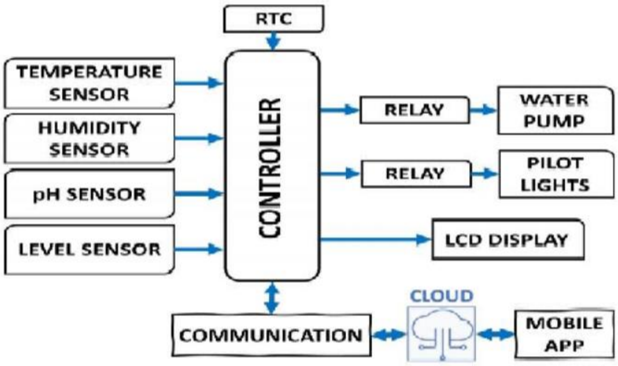

Fig -1: Monitoring and control system block diagram.

This Fig-1, shows how a control system works. A control system is a system that can monitor and regulate the behavior of other devices or systems using feedback loops. The diagram illustrates the components and connections of a control system, as well as the data flow and control signals.

B. Hardware components :

Some electronic elements used in this project are sensors, force elements, and active parameter display; all this controlled by a programmable device capable of processing information. The systemis designed to scale along with the hardware. Tab. I describes most important devices functions.

C. Design consideration for the aeroponic culture monitoring and control system :

The proposed system is implemented using the circuit diagram shown in Fig. 2, and the flowchart in Fig. 4 describes the behavior for the aeroponic culture monitoring and control system with an IoT application. Two operation states are considered: manual and automatic.

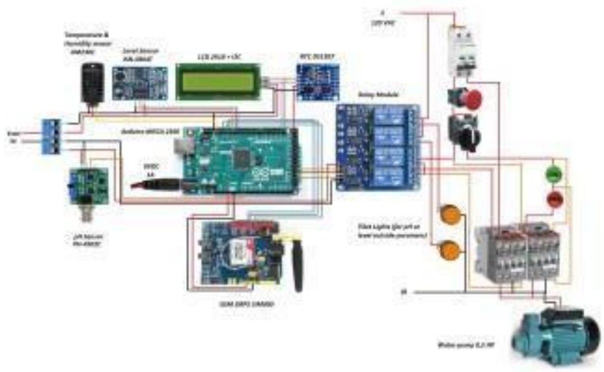

Fig -2: Control and power circuits.

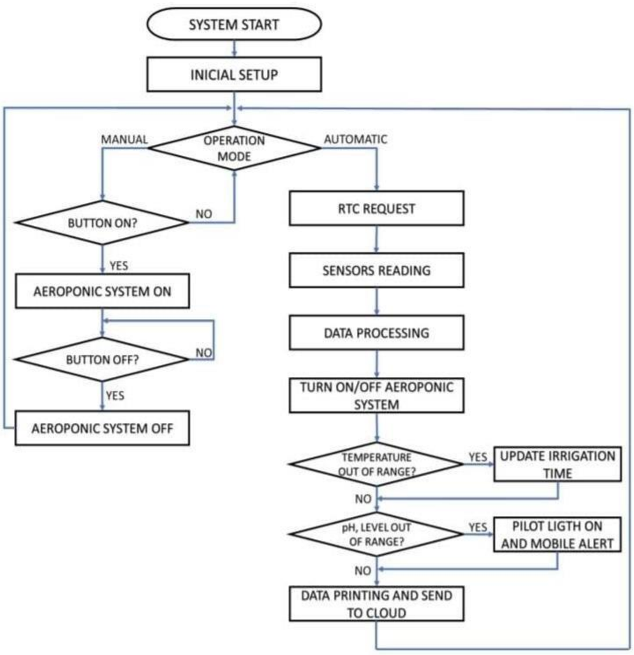

Fig -3: System flow diagram

This Fig 3, shows how an aeroponic system works. Aeroponics is a method of growing plants without soil, using mist or fog to deliver water and nutrients to the roots. The diagram illustrates the steps involved in setting up and operating an aeroponic system, as well as the data collection and feedback mechanisms.

5. CHALLENGES AND FUTURE DIRECTIONS:

Integrating machine learning (ML) into aeroponics, a soilless plant cultivation method, presents both challenges and exciting future directions. One challenge is optimizing nutrient delivery, where ML can analyze factors like growth stage and environmental conditions to ensure precise nutrient supply. Monitoring and controlling environmental parameters like humidity and temperature are crucial, and ML algorithms can automate adjustments based on real-time sensor data. Another challenge is early detection of diseases and pests, where ML can analyze images or sensor data to identify signs and enable timely intervention. Looking ahead, future directions include integrating Internet of Things (IoT) devices for real-time data collection and analysis, genetic optimization using ML to breed plants with desired traits, development of autonomous aeroponics systems driven by ML decision-making, multi- objective optimization to balance yield and resource efficiency, and collaborative learning among aeroponics facilities for industry-wide advancements in sustainable agriculture.

6. CONCLUSIONS

Aeroponics is a modern cultivation method that can be used as an alternative to conventional farming. This culture procedure improves production, eliminates pesticide use, and take advantage of the cultivable physical area. However, it demands a well-controlled surrounding climate, including adequate compensation for environmental conditions changes, precision in irrigation intervals, fault detection in the aeroponic system that shut down the nutrient supply, or other situations that can contribute to permanent plant damage. Therefore, in the present work, a supervision and control system that operates autonomously has been proposed to improve the efficiency of agricultural activities in an aeroponic crop for green leaf lettuce. The automated aeroponic system proposed, reduces errors in operation due to human intentions, and can provide the nutrients solution in the amount necessary for adequate plant growth, considering its development stages, and environmental conditions, which improves production by accelerating development due to better root oxygenation. Also, more appropriate use of water resources has been achieved. Finally, it is possible to offer continuous and hygienic vegetables throughout the year, regardless of weather conditions.

REFERENCES

[1] L. Lucero, D. Lucero, E. Ormeno-Mejia and G. Collaguazo, "Automated aeroponics vegetable growing system. Case study Lettuce," 2020 IEEE ANDESCON, Quito, Ecuador, 2020, pp. 1-6, doi: 10.1109/ANDESCON50619.2020.9272180.

[2] F. C. L. Belista, M. P. C. Go, L. L. Lucenara, C. J. G. Policarpio,
X. J. M. Tan, and R. G. Baldovino, “A smart aeroponic tailored for IoT vertical agriculture using network connected modular environmental chambers,” 2018 IEEE 10th Int. Conf. Humanoid, Nanotechnology, Inf. Technol. Commun. Control. Environ. Manag. HNICEM2018, pp. 4–7, 2

[3] M. Wang, C. Dong, and W. Gao, “Evaluation of the growth, photosynthetic characteristics, antioxidant capacity, biomass yield and quality of tomato using aeroponics, hydroponics and porous tube-vermiculite systems in bio-regenerative life support systems,” Life Sci. Sp. Res., vol. 22, no. May, pp. 68–75, 2019, doi: 10.1016/j.lssr.2019.07.008.

[4] I. Idris and M. I. Sani, “Monitoring and control of aeroponic growing system for potato production,” Proc. 2012 IEEE Conf. Control. Syst. Ind. Informatics, ICCSII 2012, pp. 120–125, 2012, doi: 10.1109/CCSII.2012.6470485.

[5] A. Garcia-Cedeno et al., “PLATANO: Intelligent technological support platform for azuay province farmers in Ecuador,” 2019 IEEE Int. Conf. Eng. Veracruz, ICEV 2019, pp. 1–7, 2019, doi: 10.1109/ICEV.2019.8920501.

[6] " IoT – Based Aeroponic System for Seasonal Plants using Fuzzy Logic " Pierce Boachard N. Bolivar,Jericka Lavern G. Clar, Mark Jewel L. Constantino,Earlron A. Roguin,Mary Grace P. Beaño
,Maria Emmalyn Asuncion D. Capuno,Eugene V. Agustin,Aldrin J. Soriano,Anna-lizaF.Sigue[2022].

[7] P. J. Mahesh, M. Naheem, R. Mubafar, S. Shyba, and S. Beevi, “New aspect for organic farming practices: Controlled crop nutrition and soilless agriculture,” GHTC 2016 - IEEE Glob. Humanit. Technol. Conf. Technol. Benefit Humanit. Conf. Proc., pp. 819–824, 2016, doi: 10.1109/GHTC.2016.7857374.

[8] "A novel sustainable aeroponic system for healthy seed potato production in India – An update" TANUJA BUCKSETH1, RAJESH K

SINGH2, JAGESH K TIWARI3, ASHWANI K SHARMA4,

SUKHWINDER SINGH5 and S K CHAKRABARTI6 [2020].

[9] F. Rahman, I. J. Ritun, M. R. Ahmed Biplob, N. Farhin and
J. Uddin, ”Automated Aeroponics System for Indoor Farming using Arduino,” 2018 Joint 7th International Conference on Informatics, Electronics & Vision (ICIEV) and 2018 2nd International Conference on Imaging, Vision & Pattern Recognition (icIVPR), Kitakyushu, Japan, 2018, pp. 137-141, doi: 10.1109/ICIEV.2018.8641026.

[10] J. Granda-Cantuna, C. Molina-Colcha, S. E. Hidalgo- Lupera, and C. D. Valarezo-Varela, “Design and Implementation of a Wireless Sensor Network for Precision Agriculture Operating in API Mode,” 2018 5th Int. Conf. eDemocracy eGovernment, ICEDEG 2018, pp. 144–149,2018,doi:10.1109/ICEDEG.2018.8372346.