Automation and Control of Hydroponic Farming Using Labview Interfaces, Arduino and Machine Learning

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Abstract - The processing at the central control interface shall be done through LabVIEW. LabVIEW shall display real-time sensor readings, actuate actuators such as pumps, valves, and lights, and develop feedback mechanisms through PID control loops regulating parameters. Thus, automation will maintain precisely those factors most important to the health and productivity of plants stable. For greater efficiency, the system is encoded with Machine Learning algorithms which analyze both historical and live data in search of growth patterns and forecast optimized control actions.

Key words - *Hydroponic, Arduino Uno, Internet of Things, NI LabVIEW, Automation.*

1. INTRODUCTION

Modern agriculture faces unprecedented challenges due to increasing global population, climate change, and diminishing arable land. Traditional soil-based farming methods are becoming insufficient to meet the growing food demand while managing resource constraints. Hydroponic farming emerges as a sustainable solution that addresses these challenges by enabling soilless cultivation with precise control over plant nutrition and environmental conditions. While traditional soil cultivation has been the preferred method, the increasing urbanization trend necessitates alternative approaches such as hydroponics, which replaces soil with water. The integration of modern technologies such as IoT, machine learning, and automated control systems has revolutionized hydroponic farming. Smart hydroponic system that leverages LabVIEW for real-time monitoring and control, combined with machine learning algorithms for intelligent decision-making and optimization. hydroponic farming system that integrates LabVIEW for real-time sensor monitoring and control with machine learning algorithms for automated decision-making. The system utilizes a network Arduino- based sensors to continuously monitor critical environmental parameters such as pH, electrical conductivity (EC), temperature, humidity, light intensity, and water flow. The collected data is visualized and processed in LabVIEW to provide an interactive user interface and dynamic control of nutrient delivery systems. Machine learning techniques are employed to analyze historical and real-time data, predict optimal growing conditions, and automate adjustments to nutrient concentration and environmental factors.

2. Body of Paper

SEC 2.1 OBJECTIVES

1. To design and develop an intelligent hydroponic farming system integrating LabView for real time monitoring and control.

2. To interface Arduino based sensors for measuring key environmental parameters such as pH, EC, Temperature, humidity, light intensity and waterflow.

3. To automate nutrient delivery and environmental adjustments for improved crop yield and resource efficiency.

4. To apply machine learning algorithms for analyzing data and predicting optimal plant growth condition.

5. To grow plants efficiently without soil by using nutrient-rich water, reducing the need for land and saving resource like water.

6. To increase crop yield and enable year-round cultivation through controlled environmental conditions for faster and healthier plant growth.

SEC 2.2 METHODOLOGY

The methodology for hydroponic farming involves designing and setting up a soil-less cultivation system where plants are grown using nutrient-rich water solutions. First, the appropriate hydroponic technique such as NFT, deep-water culture, or drip system is selected based on crop type and space availability. The system is then constructed with reservoirs, pumps, growing trays, and a medium like cocopeat or perlite.

A balanced nutrient solution is prepared and circulated to ensure continuous supply of minerals to plant roots. Environmental parameters such as pH, temperature, humidity, and light intensity are regularly monitored and controlled to create optimal growing conditions. Data on plant growth, nutrient usage, and water consumption is collected throughout the process to evaluate system performance and ensure healthy crop development.

This study follows a structured approach to develop a fully functional hydroponic farming system. The process begins with selecting suitable crops and preparing a growth medium that supports root stability. A nutrient solution is formulated and supplied to the plants using a controlled water circulation system. Sensors and monitoring tools are used to maintain ideal pH, EC, and environmental conditions. Regular observations and data collection help assess plant growth, system efficiency, and overall performance. The system is assembled by connecting these sensors to a microcontroller that processes real-time data and controls pumps and alerts based on predefined limits. Nutrient solution is prepared and circulated through the grow channels to maintain consistent root hydration. Regular calibration of sensors and periodic system checks are performed to ensure accuracy and stable operation. Data collected throughout the process is analyzed to evaluate plant health and system performance.

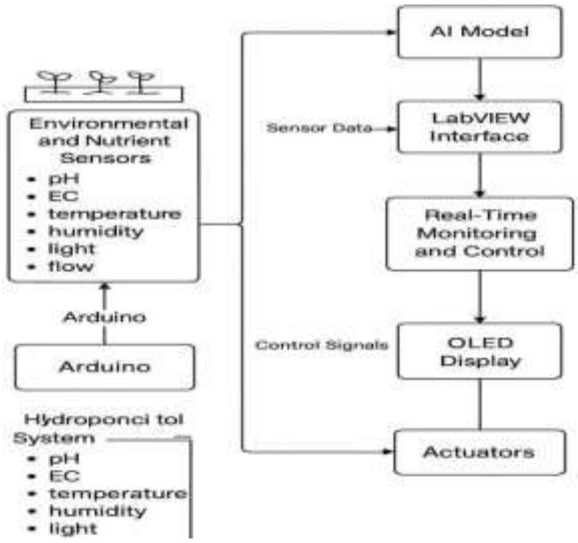

Fig 1. Block Diagram of Hydroponic System

SEC 2.3 IMPLEMENTATION

The implementation of the automated hydroponic system involves integrating sensors, actuators, and a microcontroller to manage key farming operations without manual intervention. A water-level sensor is installed in the nutrient tank to detect low levels, triggering an automatic water intake mechanism using a submersible pump. If the water level falls below the threshold, the pump is activated and an alert button on the control panel lights up to notify the user. Similarly, an overflow sensor is placed at the upper limit of the tank; when excess water is detected, the system immediately stops the pump and sends an alert message to the user through an LCD display or mobile notification. Additional automation features include pH and EC monitoring modules, automatic nutrient dosing, and scheduled LED lighting control. All system operations are monitored in real-time through the microcontroller, ensuring stable growing conditions and reducing human effort. the hydroponic system is automated by integrating water-level detection, nutrient monitoring, and pump control into a single microcontroller unit. The system continuously checks the reservoir status and manages water flow using programmed threshold values.

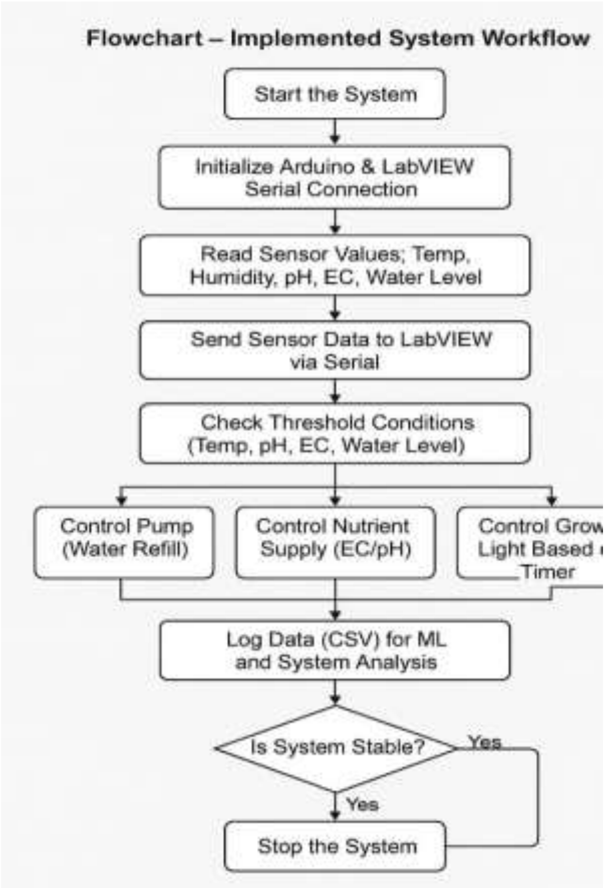

Fig 2. Flow Chart of Proposed work SEC 2.4

RESULTS

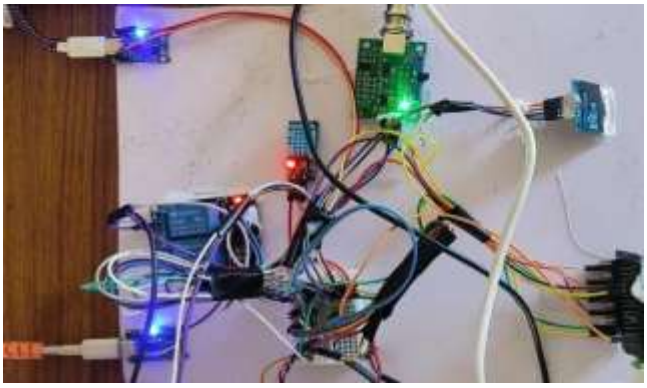

Fig 3 Working Model

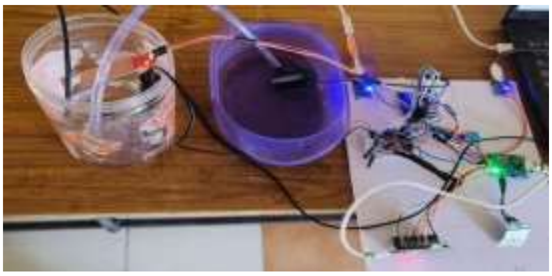

Fig 4 Water level Detection

Fig 5 Growth of plants

Fig 6 LabView Dashboard

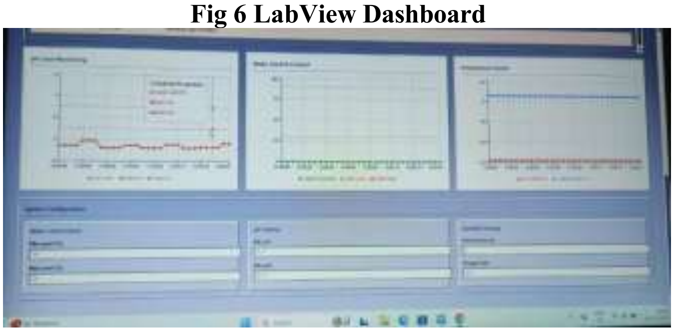

Fig 7 Display of real time hydroponic system

3. CONCLUSIONS

The development of an automated hydroponic system integrating Arduino hardware, LabVIEW interfaces, and machine-learning algorithms has proven to be an effective solution for achieving precise and intelligent plant growth management. The system successfully monitored key environmental parameters such as pH, EC, temperature, humidity, and water level, and maintained them within optimal ranges through automated nutrient dosing and control mechanisms. The real-time LabVIEW dashboard enhanced visualization, ease of operation, and quick decision-making, making the system user-friendly even for non-technical users. Overall, the project demonstrates that combining embedded systems, software interfaces, and intelligent algorithms can significantly enhance the performance and reliability of hydroponic farming. This approach provides a scalable and cost-effective model suitable for both small-scale growers and commercial farming applications.

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