Automated Hydroponics Nutrition Plants Systems Using Microcontroller

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***Abstract*— An automated hydroponic nutrition system using an Arduino microcontroller. The system controls nutrient solution flow and monitors plant environment data like fluid level and temperature using sensors. Data is displayed on an LCD screen for easy monitoring and adjustment. This integration of technology with agriculture improves nutrient delivery, resource efficiency, and plant health monitoring, highlighting the synergy between computer science and agriculture for sustainable food production. The aim of this project is to develop an automated hydroponic nutrition system using a microcontroller. This system will control the flow of nutrient solution to hydroponic plants automatically while also providing real-time data on fluid levels and environmental conditions. The project aims to improve the efficiency of nutrient delivery, enhance plant health monitoring, and demonstrate the integration of technology with agriculture for sustainable food production.**

***Index Terms*—Arduino Uno, ultrasonic sensor, dht11, relay module, water pump.**

I. INTRODUCTION

In the realm of plant care, ensuring the health and vitality of plants is a fundamental task, encompassing various aspects such as watering, rejuvenation, and fertilization. With the diverse array of plant types and their specific care needs, manual maintenance can become labor-intensive and challenging to manage effectively. However, water remains a universal lifeline for all plants, particularly in hydroponic systems where plants rely solely on nutrient-rich water for sustenance.

Hydroponic plants, cultivated without soil in various media like Rockwool, sponge, or coconut powder, require meticulous attention to watering and nutrient replacement schedules for optimal growth and productivity. The sheer volume of hydroponic plants owned by individuals or businesses underscores the need for an automated watering system to alleviate the burden of manual care.

The advancement of computer science, notably in microcontroller technology, presents an opportunity to revolutionize plant care practices. Leveraging the capabilities of microcontrollers, particularly the Arduino Uno Microcontroller and the ATmega328 board, offers a viable solution to automate watering tasks for hydroponic plants.

This project aims to address the pressing need for automation in plant care by developing an automated tool based on Arduino Uno Microcontroller technology. The Arduino Uno will serve as the central control unit, overseeing the monitoring and management of hydroponic plants. A proximity sensor, such as the Ultrasonic HC-SR04, will assist in detecting the water level within the hydroponic system. Additionally, temperature sensors, such as the DHT11, will be deployed to measure the ambient temperature and humidity surrounding the plants. The data collected by the sensors will be processed and displayed on an LCD screen, providing real-time feedback on the water level and room temperature and humidity. By integrating technology with agriculture, we aim to contribute to the advancement of the agriculture industry and promote sustainable practices in plant cultivation.

II. RELATED WORK

Hydroponics has emerged as a promising alternative for plant cultivation, particularly in areas with limited land availability. Numerous studies have explored the functionality and benefits of hydroponic systems, with a focus on nutrient control and automation using microprocessor technology.
Kumar and Cho [2] highlight the significance of using microprocessors for nutrient control in hydroponic

systems, emphasizing the potential for efficient nutrient delivery and waste reduction. They suggest that waste nutrients from hydroponic plants can be recycled, contributing to sustainability in agriculture.

In the realm of processor-based hydroponic growth systems, virtual instrument systems like LabVIEW offer enhanced control capabilities [4]. This approach enables precise monitoring and adjustment of environmental parameters, fostering optimal plant growth conditions.

Another area of research focuses on the development of automatic microcontroller systems for Deep Water Culture (DWC), providing insights into hydroponic water culture methodologies and pH sensor measurements [5]. This work emphasizes the importance of maintaining water levels and pH balance in hydroponic reservoirs for successful plant cultivation.

Studies on hydroponic nutrient solution control systems and factor analysis have addressed challenges in automation and control [6]. These efforts aim to optimize nutrient delivery and address complexities encountered during the automation process.

Research by Wang et al. [7] delves into real-time monitoring of aquaponic plants, leveraging the Internet of Things (IoT) to transmit plant data to smartphones. This approach enables remote monitoring and management of plant health parameters, enhancing accessibility and convenience for growers.

Additionally, Mishra and Jain [8] have explored automatic addition of nutrients using electrodes as benchmarks for nutrient levels. Their system activates nutrient pumps based on sensor readings, ensuring timely and precise nutrient supplementation for hydroponic plants.

In the context of automatic plant watering, Devika et al. [9] have developed systems for soil-based plant cultivation. Their approach utilizes humidity sensors to detect soil moisture levels, triggering automated watering when soil moisture is insufficient.

These related works underscore the growing interest in automation and control technologies for optimizing plant care processes in hydroponic and soil-based cultivation systems. By leveraging advancements in microcontroller technology and sensor integration, researchers aim to enhance efficiency, sustainability, and productivity in agriculture.

III. HYDROPONICS NUTRITION PLANTS SYSTEMS AND PROTOTYPE

The automatic hydroponics nutrition plant system utilizes a specialized chamber or vessel to house the plants, with nutrients delivered directly to the hydroponic roots as needed. The system is controlled by an Arduino Uno microcontroller, which enables automatic regulation of water (nutrient) flow to the vessel. Additionally, the microcontroller can be remotely controlled via an Android smartphone.

The program module embedded in the system enables real-time setting of alarms on nutrient pumps using the Arduino Uno microcontroller. When the alarm is enabled, the relay is activated, initiating nutrient solution delivery to the hydroponic plants. Conversely, when the alarm is deactivated, the relay is deactivated, halting nutrient supply.

To facilitate remote monitoring and control, a Arduino application is designed for Android smartphones. Before designing the Arduino application, data storage is provisioned using the features of thingspeak.com.

The hydroponic flow system begins with the detection of a proximity sensor and a temperature sensor, as depicted. The proximity sensor detects the water level in the hydroponic tube, while the temperature sensor monitors the room temperature. The sensor outputs are connected to a relay linked to the microcontroller port. When the relay port pin indicates that the water level is below the specified height, the water pump is activated to irrigate the hydroponic plants. Conversely, if the water level is above the specified height, the water pump is deactivated, ensuring regular water circulation. In addition to water delivery, nutrient pumps are utilized to add nutrients to the hydroponic tube. Water pumps facilitate water recirculation, with relays regulating both water entry and exit pumps.

IV. TECHNICAL SPECIFICATION

Arduino Uno**:** The Arduino Uno is a popular microcontroller board that serves as a foundation for countless electronics projects. Based on the ATmega328 microcontroller, providing the processing power for your projects. Equipped with 14 digital pins that can be configured as inputs or outputs.

Of these, 6 can generate pulse-width modulation (PWM) signals, allowing for precise control of analog devices like LEDs or motors. Includes 6 analog input pins, enabling the board to read analog sensors and signals. Operates at 16 MHz, providing fast and efficient execution of program instructions.

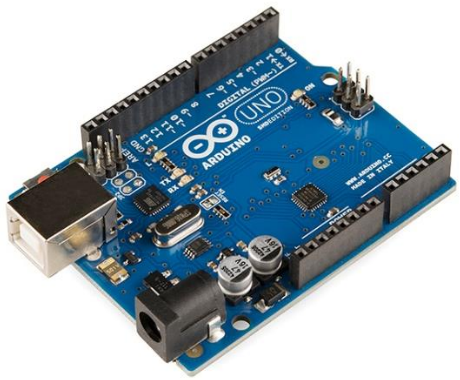

Fig.1: Arduino uno

Ultrasonic sensor

An ultrasonic sensor works by emitting high-frequency sound waves (ultrasonic pulses) from a transducer. These sound waves travel through the air and bounce off objects in their path. The sensor then detects the reflected waves and measures the time it takes for them to return. By knowing the speed of sound in air and the time taken for the waves to return, the sensor can calculate the distance to the object. This information is then used to determine the object's proximity to the sensor. Ultrasonic sensors are commonly used in various applications such as object detection, distance measurement, and even in robotics for navigation purposes.

Fig.2: Ultrasonic sensor

LCD Display

The LCD (Liquid Crystal Display) 16x2 is a popular alphanumeric display commonly used with microcontrollers like the Arduino Uno. The "16x2" designation refers to the size of the display. It has 16 columns and 2 rows, allowing it to display up to 16 characters per row.

Fig.3: LCD display 16x2

Water Pump

Fig.4: water pump

This pump is designed to be submerged in water, making it suitable for applications where the pump needs to operate underwater, such as in aquariums or fountains. The pump has a power rating of 0.046 horsepower (hp), indicating its ability to deliver a certain amount of power to move water. This power rating gives an indication of the pump's capability to handle the intended tasks effectively.

Relay Module

A relay module is an electronic device used to control high-power circuits with low-power signals. The relay module operates at a voltage of 12 volts DC (Direct Current), making it compatible with standard 12V power sources commonly found in electronics projects. It consists of a relay that can switch high-power circuits on or off in response to a low-power input signal. This enables the control of devices such as lights, motors, or other electrical appliances using a microcontroller or other low-power control circuitry.

Fig.5: Relay module

V. BLOCK DIAGRAM

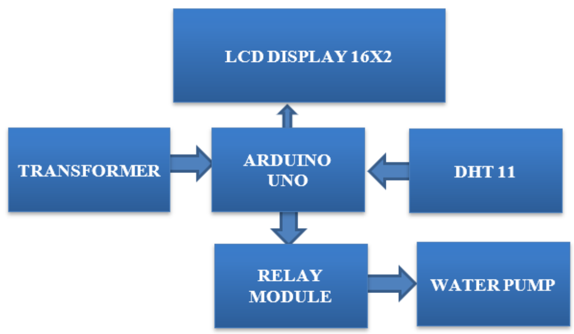

Fig.6: Block diagram

This is used to provide power to the Arduino and other components. It typically converts AC mains voltage (e.g., 110V or 220V) to a lower DC voltage suitable for electronics. Connect the output of the transformer power supply to the appropriate input of the Arduino board. The Arduino board acts as the central control unit for the project. Connect it to the transformer power supply to provide power. Use the digital and analog pins on the Arduino to connect to other components as described below. Connect the VCC pin of the ultrasonic sensor to the 5V output of the Arduino, GND to GND, and the Trig and Echo pins to digital pins on the Arduino. Connect the VCC pin of the DHT11 sensor to the 5V output of the Arduino, GND to GND, and the data pin to a digital pin on the Arduino. Connect the VCC pin of the LCD display to the 5V output of the Arduino, GND to GND, and the SDA and SCL pins to the corresponding I2C pins (A4 and A5) on the Arduino. You may need to install a library for I2C communication with the LCD display. Connect the VCC pin of the relay module to the 5V output of the Arduino, GND to GND, and the control input pin(s) to digital pins on the Arduino. Connect the power supply for the water pump to the relay module. The water pump can draw high current, so ensure that the relay module can handle the load.

VI. RESULT ANALYSIS

Evaluate how accurately the system maintains the water level in the hydroponics setup. Measure the actual water level against the desired level set by the user and analyze any discrepancies. Assess the effectiveness of the water pump and nutrient dosing system in delivering the right amount of nutrients to the plants. Monitor plant health and growth over time to determine if the system provides adequate nutrition. nalyze the accuracy of temperature and humidity readings provided by the DHT11 sensor. Compare these readings with external reference measurements to verify their reliability. valuate the overall stability and reliability of the system over an extended period. Assess factors such as sensor drift, component failures, and system errors to identify any areas for improvement. Assess the usability and effectiveness of the LCD display interface. Evaluate whether it provides clear and informative feedback to the user about the system's operation and status. Measure the power consumption of the system and assess its energy efficiency. Identify any opportunities for optimization to reduce power consumption and improve sustainability. Monitor the system's performance over an extended period to assess its long-term reliability and durability. Identify any maintenance requirements or issues that arise over time.

The Arduino board serves as the brain of the hydroponics system, controlling and coordinating the operation of various components. It reads sensor data, controls the water pump through the relay module, and displays information on the LCD display. The ultrasonic sensor is used to measure the water level in the hydroponics system. It emits ultrasonic pulses and measures the time it takes for the pulses to bounce back from the water surface, providing accurate distance measurements. The DHT11 sensor monitors the ambient temperature and humidity inside the hydroponics system. This data is crucial for maintaining optimal growing conditions for the plants. The LCD display provides real-time feedback on the system's operation, displaying information such as water level, temperature, humidity, and pump status. This allows users to monitor the system easily and make any necessary adjustments. The relay module controls the operation of the water pump based on sensor readings. When the water level falls below a certain threshold, the Arduino triggers the relay to turn on the water pump, ensuring that the plants receive adequate water. Once the desired water level is reached, the relay is turned off to stop the pump. The water pump circulates nutrient-rich water to the hydroponic plants, ensuring they receive the necessary nutrients for growth. It is activated and deactivated by the relay module based on the water level detected by the ultrasonic sensor.

Fig.7: Nutrition

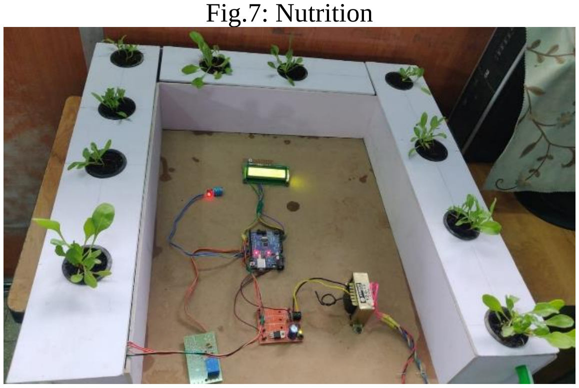

Fig.8: Actual model of hydroponic

Fig.9: Water level of tank

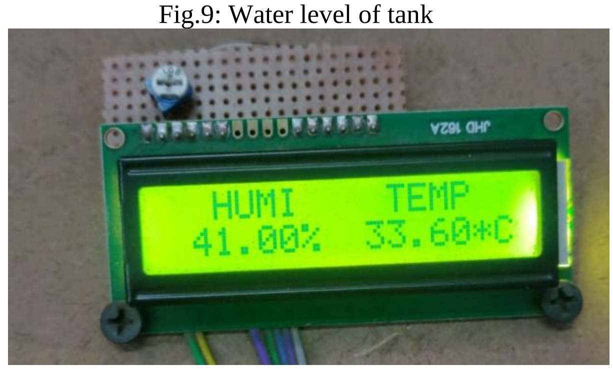

Fig.10 Humidity & temperature reading

Time	Temperature Sensor	Height (Ultrasonic Sensor)	Humidity	Motor Status
1:00	37.2	5	13	on
2:00	37.1	4	11	on
3:00	37.2	5	10	on
4:00	35.1	6	16	off
5:00	35.9	5	17	off
6:00	35.8	5	18	off
7:00	35	4	19	off

Observation Table: Time, Temperature Humidity, Height and Motor status

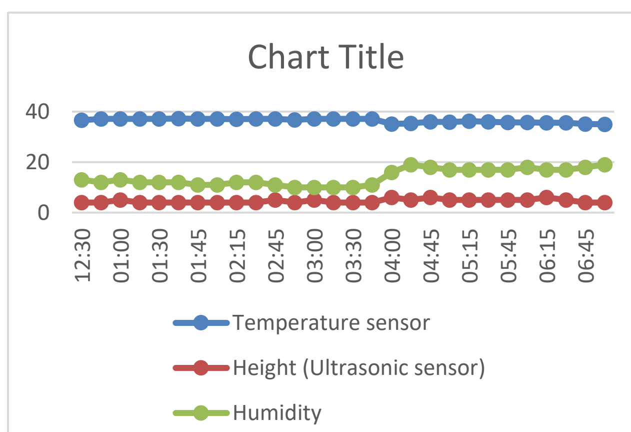

Fig.11 Graph Temp vs. Height vs. Humidity

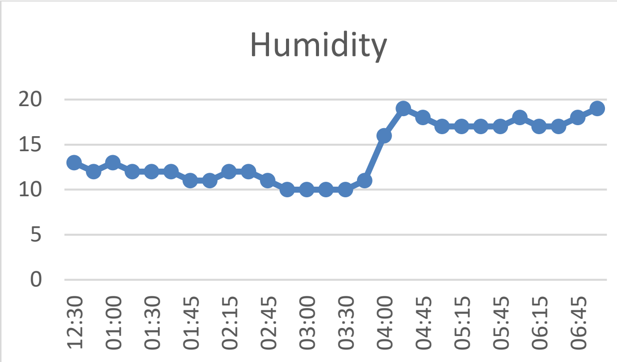

Fig.12 Humidity vs. Time

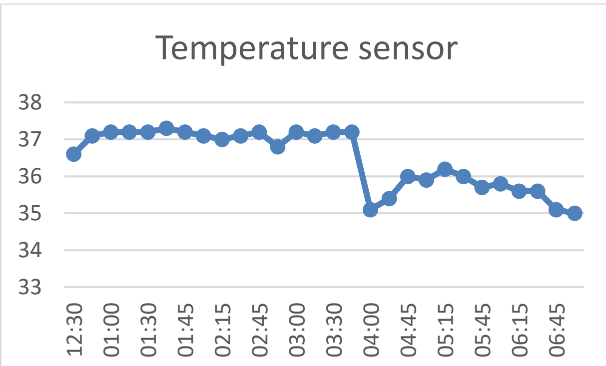

Fig.13 Temp vs. Time

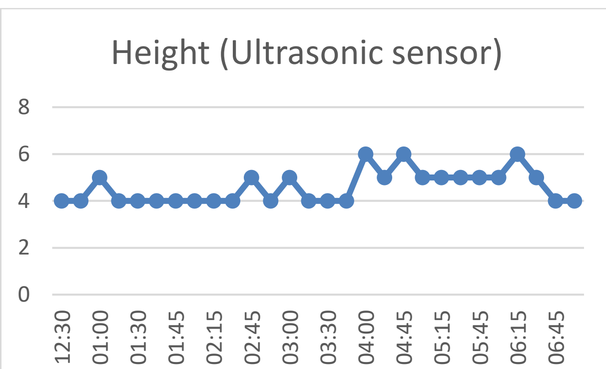

Fig.14 Height vs. Time

The graphs depict changes in temperature, humidity, ultrasonic sensor height, and motor status over time. Taking readings during the summer is a crucial aspect of result analysis for a hydroponics system, as environmental conditions can significantly impact plant growth and system performance during this time. temperature and humidity readings can vary significantly between seasons, with high temperatures and low humidity typically observed during the summer months in many regions. Conversely, other seasons such as autumn or winter may experience cooler temperatures and higher humidity levels. In figure 11, 12, 13 and 14, Temperature fluctuates between 35°C and 37.3°C. Overall, it remains relatively stable with minor variations. Humidity ranges from 10 to 20. Shows fluctuations indicating changes in environmental moisture levels. Sensor height varies from 1 to 7. Reflects changes in distance between the sensor and its target. Indicates periods of motor activity (on) and inactivity (off). Clear transitions between motor operation states.

VII. CONCLUSION

An automation system for hydroponic plant irrigation using Arduino Uno Microcontroller based on Android is presented in this paper. Nutritional water flow system by utilizing sensor distance has been successfully done. The water level in the hydroponic tube can be adjusted according to the need of hydroponic, and this is made into a basic guideline for watering or not. The sensor results are sent to Arduino Uno microcontroller and communication with an Android smartphone. Likewise, the temperature setting has been successfully done well. The room temperature can be determined according to his needs. In our experiments, it was shown that the mixture of water and nutrients was automatically transferred to plant roots in hydroponic tubes. The water level is maintained up to 6 cm in hydroponic tubes because the system will drain water periodically if there is a water shortage.

FUTURE SCOPE

The future scope of hydroponics presents exciting opportunities for revolutionizing agriculture and food production. Hydroponics is the fastest growing sector of agriculture. The hydroponics techniques produce a yield 1,000 times greater than the same sized area of land could produce annually. Best of all, the process is completely automated, controlled by robots using an assembly line type system, such as those used in manufacturing plants. The shipping containers can be transported to other countries also.

REFERENCE

[1] Wang D, Zhao J, Huang L and Xu D 2015 Design of A Smart Monitoring and Control System for Aquaponics Proc. of the 5th Int. Conf. on Information Engineering for Mechanics and Materials (ICIMM 2015) pp 937-942.

[2] Velazquez L A, Hernandez M A, Leon M, Dominguez R B and Gutierrez J M 2013 First Advances on the Development of a Hydroponic System for Cherry Tomato Culture Proc. of IEEE 10th Int. Conf. on Elect. Eng. Comp. Sc. and Automatic Control (CCE).

[3] Kumar RR and Cho JY 2014 Reuse of Hydroponic Waste Solution Environ Sci Pollut Re Int http://link.springer.com/article/10.1007/s11356-01430243.

[4] Asumadu J A, Smith B, Dogan N S, Loretan P A and Aglan H 1996 Microprocessor-Based Instrument for Hydroponic Growth Chambers Used in Ecological Life Support Systems Instrumentation and Measurement Technology IEEE Instrumentation and Measurement Technology Conf. 1 pp 325-329.

[5] Saaid M F, Yahya N A M, Noor M Z H and Ali M S A M 2013 A Development of an Automatic Microcontroller System for Deep Water Culture (DWC) IEEE 9th Int. Colloquium on Signal Processing and its Applications.

[6] Chenzhong Y, Yinchun H and Weihong Z 2004 Research of Hydroponics Nutrient Solution Control Technology Proc. 5' World Congress on Intelligent Control and Automation 1.

[7] Shafahi M and Woolston D 2014 Aquaponics: A Sustainable Food Production System Proc. of the ASME 2014 International Mechanical Engineering Congress and Exposition.

[8] Mishra R L and Jain P 2015 Design and Implementation of Automatic Hydroponics System Using ARM Processor Int. J. of Advanced Research in Electrical, Electronics and Instrumentation Engineering 4.

[9] Devika S V, Khamuruddeen S, Khamurunnisa S, Thota J and Shaik K 2014 Arduino Based Automatic Plant Watering System Int. J. of Advanced Research in Comp. Sc. and Software Engineering 4 pp 449-456.