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Hydroponics Monitoring and Control System

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Abstract*: This paper presents the design and construction of a hydroponics monitoring system that can collect parameters of hydroponic systems, such as temperature, water limit, pH level, and nutrient levels. The monitoring system was developed using an ESP32 microcontroller and several sensors, including total dissolved solids (TDS), pH, water level, and temperature sensors. The ESP32 microcontroller gathers and processes data from the sensors to automatically activate the water or salt pump and drain the necessary materials into the hydroponic system's plant basin. The user can then view the hydroponic parameters through the Blynk application on a smart phone. The user can also activate the pumps for water, nutrients, or salt using the application's interface on a smart phone, or the ESP32 microcontroller can activate them automatically if the parameter values deviate from the required values.*

Keywords: hydroponics monitoring

I. INTRODUCTION

Hydroponics is a technique of using water and fertilizer solutions as the growing medium, increasing productivity through monitoring of environmental conditions compared to traditional agricultural methods [1]. In a hydroponic system, plants are kept in tubs, and their roots float in nutrient-rich liquid, allowing them to develop rapidly and become a mass.

Hydroponics, which translates to “water work”, comes from the Greek terms hydro, which means “water”, and ponos, which means “labor” [2]. This type of irrigation is frequently used in areas where the soil is not fertile enough to support crop production[3].

The problem that this study attempts to solve is how to reduce farmers' efforts in checking the elements that the plant needs without the requirement for farmer intervention.

II. LITERATURE SURVEY

Hydroponics system uses nutrient-rich water as the growing medium for plants. The use of hydroponic systems in agricultural technology has grown significantly. It has the potential to partially replace conventional soil-based growth methods in global food production [10]. One benefit of hydroponic growing systems is the ability to control environmental factors to maximize production in vertical gardens to constrained spaces. Other benefits include reducing water waste through recirculation, growing crops in controlled environments (such as monitoring nutrition, plant pests, and other aspects necessary for optimal growth of plants), and the ability to control circumstances to increase the output of vertical gardens in limited spaces[11].

Kularbphyt tong et al. [12] developed a mechanism for controlling plant growth. This system can regulate essential environmental elements that affect a plant's growth, such as temperature, humidity, and water. The application system automatically blends the chosen solution to determine the correct amount, collects data on the quantity of solution mixed during planting, and may be used to assess the cost of producing vegetables and determine the profitability of each produce to help with growth decisions.

Huo-etal. [13] explored the influence of microalgae on vegetable growth and evaluated the nutrient removal in the greenhouse for three kinds of vegetables produced hydroponically in greenhouses using nitrate-rich synthetic wastewater. The results indicated that most vegetable types produced more as a response to the use of microalgae as a technique of sustainable production system.

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Puno et al. [14] developed a hydroponics system that combines fuzzy logic control and nutrient film technology. Several crops can be grown within a limited space using this technique. The main parameters for crop survival were monitored, and fuzzy logic was used to drive the pumps for the tanks holding fresh water and nutrient concentrates. The drains of the mixing tanks were also monitored using data from sensors that detected electrical conductivity, pH, and water levels in the tank.

Ramos et al. [15] developed a hydroponics system with a nutrient film technique to investigate and create algorithms that will enable effective water recirculation, resulting in electricity savings of about 40% compared to conventional systems.

III. EMBEDDED SYSTEM

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions, sometimes with real-time computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts.

In contrast a general purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today as they control many of the common devices we use. Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass- produced, benefiting from economies of scale[5].

Physically embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular kind of application device. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines, and toys (as well as the more obvious cellular phone and PDA) are among the myriad possible hosts of an embedded system. Embedded systems that are programmable are provided with a programming interface, and embedded systems programming is a specialized occupation. Certain operating system platforms are tailored for the embedded market, such as Embedded Java and Windows XP Embedded. However, some low-end consumer products use very inexpensive microprocessor sand limited storage, with the application and operating system both part of a single program. The program is written permanently into the system's memory in this case, rather than being loaded into RAM (random access memory), as programs on a personal computer.[5]

IV. EXISTING SYSTEM

A hydroponic monitoring and control system project using embedded systems involves creating a setup to manage and optimize the growth of plants in a hydroponic environment. This system typically includes sensors to monitor factors like temperature, humidity, pH levels, and nutrient levels, along with actuators to control elements such as water pumps, nutrient dosing, and lighting. Embedded systems, like microcontrollers or single-board computers, are used to gather data from sensors, process it, and make decisions to automate the hydroponic system for optimal plant growth."

V. PROPOSED METHOD

The proposed system aims to design and implement an embedded system for monitoring and controlling hydroponic environments. It will include sensors to measure essential parameters such as pH levels, nutrient concentrations, temperature, humidity, and light intensity. The system will also feature actuators to control elements like water pumps, nutrient dosing systems, and artificial lighting. Data collected from sensors will be processed and displayed on a user interface, providing real-time monitoring of the hydroponic setup. Users will be able to remotely access and control the system through a mobile application or a web interface.

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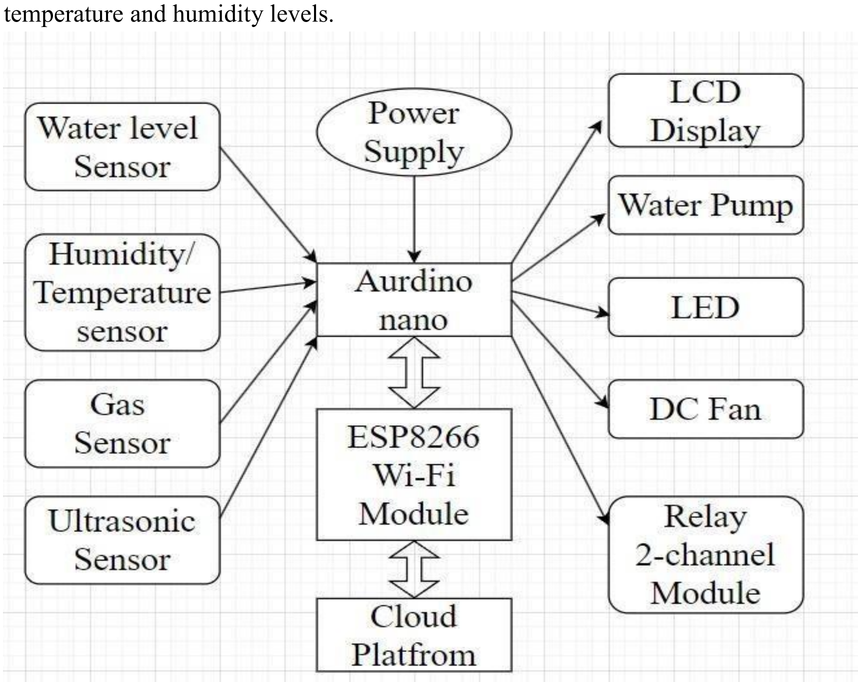
VI. WORKING PRINCIPLE

Hydroponics monitoring and control systems are essential for maintaining optimal growing conditions for plants in a soilless environment. Here's a detailed explanation of how these systems work:

- **Sensors:** Various sensors are used to monitor key parameters of the hydroponic system. These sensors include:
- **EC/TDS Sensors:** Measure the electrical conductivity (EC) or total dissolved solids (TDS) in the nutrient solution, which indicates the concentration of nutrients available to the plants.
- **Temperature and Humidity Sensors:** Monitor the temperature and humidity levels in the growing environment, which can affect plant growth and health. **Light Sensors:** Measure the intensity and duration of light, which is crucial for photosynthesis.
- **Dissolved Oxygen Sensors:** Monitor the level of oxygen dissolved in the nutrient solution, which is important for root health.
- **Pumps:** Used to circulate and distribute the nutrient solution.
- **Lights:** LED lights are often used in hydroponic systems to provide the necessary light for plant growth. Actuators control the intensity and duration of light.
- **Fans:** Control the airflow and ventilation in the growing environment, which is important for maintaining optimal temperature and humidity levels.



VII. SOFTWARE USED

Arduino is a prototype platform (open-source) based on an easy-to use hardware and software. It consists of a circuit board, which can be programmed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board.

VIII. RESULT

The completed prototype of the hydroponic monitoring system is shown in the fig. The ESP 32 controller were programmed with the Embedded application, and connectivity was established. The experiments proved that monitoring of the hydroponics system was successfully carried out. Most of the results, except for temperature, were constant because the system compensates for changes in water, salt, or nutrition liquid.

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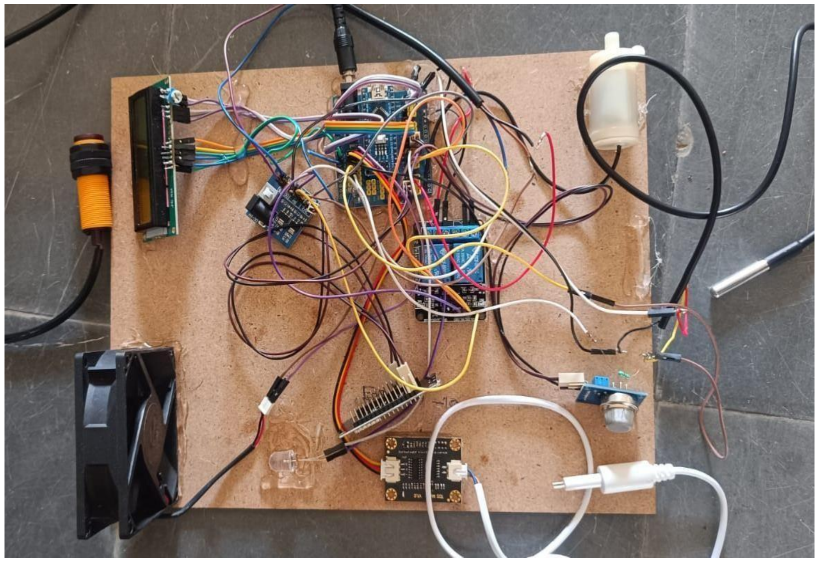

Fig. Circuit diagram of Hydroponics Monitoring and Control System

IX. CONCLUSION

A hydroponics monitoring system is designed and fabricated based on an ESP32 microcontroller and integrated with Wi-Fi technologies as an interface to assist farmers or owners of hydroponic farming systems. Based on the data collected from sensors in the plant basin, the ESP32 microcontroller automatically activates the water, phosphoric acid, and fertilizer pumps (N, P, and K). TDS, water level, and temperature sensors are also integrated into the developed hydroponics monitoring system. Temperature, water limit, pH level, and EC levels are measurable parameters in a hydroponics monitoring system. The Wi-Fi interface on the hydroponic monitoring and management system enables the control and monitoring of the hydroponics parameters of agricultural systems using the Blynk mobile application. This system can be easily obtained on the market at a relatively affordable price, and it can be implemented in the hydroponics system to enhance the plant growth. In this study, the monitoring of hydroponics system and IoT interface were effectively developed and implemented.

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