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Hydroponics System using IoT

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Abstract: Hydroponics is the method of cultivating plants without soil. Water with oxygen and required minerals acts as the cultivation medium. Hydroponics improves the quality of crops and increases crop yield, but it requires skilled labor to monitor and control it. Hydroponics is a method of Controlled Environment Agriculture (CEA), which helps close monitoring of plants for a better and successful yield where the soil may not support its maximum yield. Smart hydroponics system allows automation in the field of hydroponics to monitor and regulate growth conditions for the plant. The proposed system aims at automating the Hydroponics setup using an ESP 8266 through IoT. One main advantage of using the ESP 8266 is the reduced cost of the overall build. Though Hydroponics is efficient when it comes to the usage of resources, it can prove to be expensive with each block of the plants requiring specified electronic equipment and hardware to monitor them. One of the main aim of this project will be to ensure cost effective build that can be affordable by farmers and cultivators in order to make sure they get maximum profit and reduced wastage of resources.

Keywords: IoT, pH Sensor, Temperature and Humidity Sensor, ESP -8266/Node MCU, smart farming, MQTT Protocol.

I. INTRODUCTION

Due to the advancements in the field of Controlled Environment Agriculture (CEA), particularly Hydroponics, a demand has risen for need of a technology to automate and monitor the same. Hydroponics system were introduced in areas where the farmers failed to get sufficient yield. This helped many of them together with the cause of food production. Apart from helping the farmers and cultivators, the hydroponics system collects and provides data for research purposes. The requirements of each plant can be duly noted by the system and can alert the front-end user about the same. The present environmental conditions are also monitored and displayed to the front-end user. These data can be used to meet the exact requirements of the plants without the use of excess resources and still meet the maximum yield record. Introduction of automation in this system can significantly reduce labor as well as human error. The automation process provides the required amount of water and nutrients all by itself and created a log for the user's reference.

However, automation in hydroponics is an existing system; having said that, the main aim of the proposed model is to build a cost-effective system compared to the currently available systems.

One factor that reduces the cost significantly in our proposed system is the use of ESP 8266 instead of the usually used Arduino. Cost can be cut down further by using economically effective sensors. These factors will help in building of a cost effective system. ESP8266 is a microchip that uses Wi-Fi for connectivity.

It has the ability to function as a microcontroller. PVC pipes can be used as containers in case of a small scale setup. To sense the temperature, DH22 sensors are used. These are easily available. A pH sensor is used to check the acidity/basicity level of the soil, solvent and atmosphere. The sensors communicate with the microcontroller through the MQTT protocol. For the supply of required amount of water, a Stepper motor is used.

II. LITERATURE REVIEW

Till date, various methodologies have been adopted by Engineers to increase crop yield and to automate the process. In this modern era of technology, it has become a necessity to adopt newer and efficient systems to carter the needs of the society. Some of the existing articles are studied below.

In [1], the author has proposed a methodology by which the intensity of the lights are maintained at 25% when there are no commuters and the intensity is increased with increasing number of vehicles. The presence of vehicles is monitored using infra-red sensors. When vehicles pass through the road, the brightness of the LED light is increased to 50% and further increase in the number of vehicles causes the intensity to increase and reach 100% when there is busy traffic.

In [2], the authors have briefed Pulse Width Modulation and have developed a mathematical model for the same. The scope of Pulse Width Modulation in energy conservation has also been discussed.

In [3], an effective situation-based traffic adaptive control is followed. The module uses traffic sensors to monitor traffic and a street light coordinator module analyzes the traffic volume and issues commands to the streetlights which are connected through Zigbee. This module also facilitates the transfer of the observed traffic data to a common management platform through 3G network.

In [4], an efficient approach for charging multiple portable Lithium-ion batteries from solar energy using solar cell is discussed. The technique followed is significant and efficient.

In [5], two techniques for adjusting brightness of LEDs have been discussed, Pulse Width Modulation and varying brightness by changing Modulation depth. An additional aspect of using these brightness adjusting techniques to facilitate Visible-light communication has also been elaborated.

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From the above literature survey we have proposed a superior and fully automatic stand-alone module to monitor and efficiently automate a Hydroponic setup. The system can be easily installed and is engineered in such a way that even laymen can easily understand and use it.

III. SYSTEM DESCRIPTION

The Hardware consists of an ESP 8266 or a Node MCU, pH sensor, DH22 sensor, DS 18B20 temperature sensor, LED lights, water pump, relay switch, stepper motor. These sensors are installed at appropriate locations for data acquisition. They monitor different parameters like ambient lighting, presence of an approaching vehicle etc.

A. ESP 8266/ Node MCU

The ESP 8266 is a WiFi microchip with microcontroller capabilities. It has 16 GPIO pins. And the maximum operating voltage of ESP 8266 is 5v. The operating voltage is 3.3V and it can handle up to 5V. It has a USB connector, a power jack and a reset button. It serves as an interface between internet and the hardware components.

B. pH Sensor

pH is the measure of hydrogen ion concentration of a solution, identifying the acidic or alkaline nature of the solution. pH sensor is an instrument used to measure the pH value of the solution. It has a reference electrode and a measuring electrode, the voltage produced between the electrodes is proportional to the pH of the solution. An ideal pH sensor outputs 0 volts at neutral pH, a positive voltage at acidic range and negative voltage at basic range.

C. DH22 Temperature Sensor

DH22 is a digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the atmospheric temperature. This sensor outputs a digital signal to the microcontroller.

D. DS18B20 Temperature Sensor

DS18B20 is a digital temperature sensor capable of measuring temperature values underwater. It looks like a probe placed underwater and outputs a digital value to the microcontroller.

E. LED Lights

Lighting influences the plant growth to a considerable extent. Combination of Red, Blue and Green LEDs are used to provide the required lighting for plants. The RGB spectrum is modified according to the requirements of the respective plant being cultivated.

F. Water Pump

Water pump is used to pump water from the reserve tank to the hydroponic gully to the plants. The water pump is controlled by the microcontroller through a relay switch.

G. Relay Switch

The relay is an electronically operated switch which can be controlled by the microcontroller's 5v output to operate any appliance.

IV. SYSTEM IMPLEMENTATION

A. General Working Principle

The design designates about the working of a fully automatic hydroponic setup with remote monitoring capabilities. Figure1 shows the system architecture of the proposed module. The setup has an ESP 8266 microcontroller, pH sensor, DS18B20 sensor, DH22 temperature sensor and a water pump controlled through a relay; the module combines the values from the sensors and then it is converted to JSON. The string generated is then sent to the server through a MQTT broker. The values from the server are accessed through a web application. The web application is developed with a simple and easily understandable UI. Figure 2 shows the functional block diagram of the proposed module.

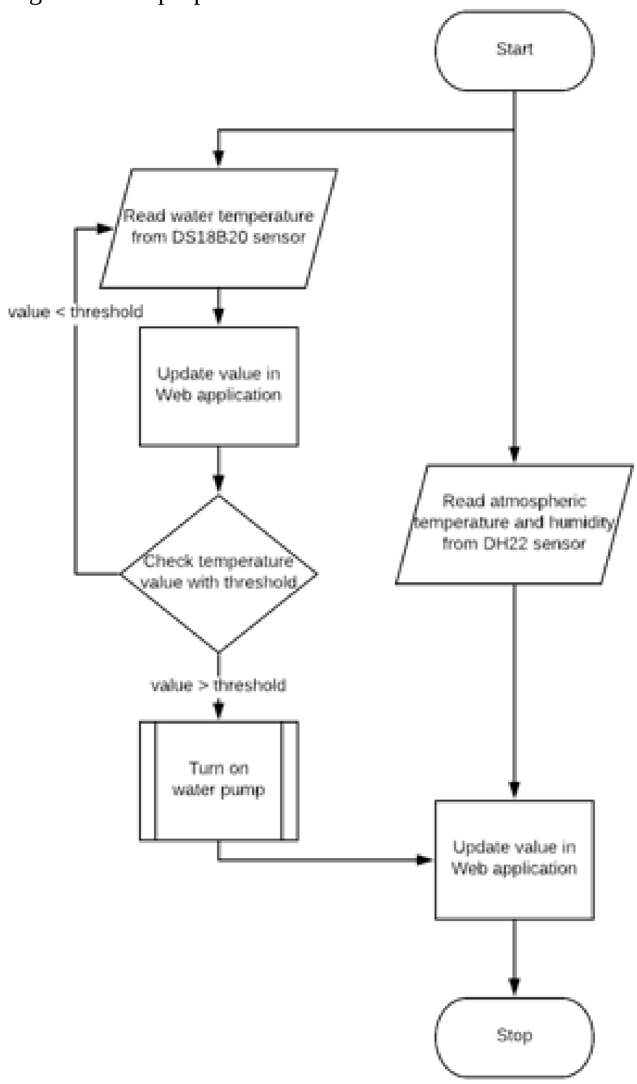

Figure 2: Functional Block Diagram of Temperature Monitoring Module.

The module can be divided into three based on functionality. The monitoring part, uploading to the cloud and controlling the module through the web application. Numerous sensors are mounted at appropriate positions in the module to facilitate monitoring of the parameters like temperature, pH, water temperature etc.

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These sensors output digital and analogue values which are read by the microcontroller and is used for further processing. The values are compared with the threshold values of the respective parameters values corresponding action is carried out. These values from sensors are combined into a string. The string is then converted to JSON which is sent to the server through a MQTT broker.

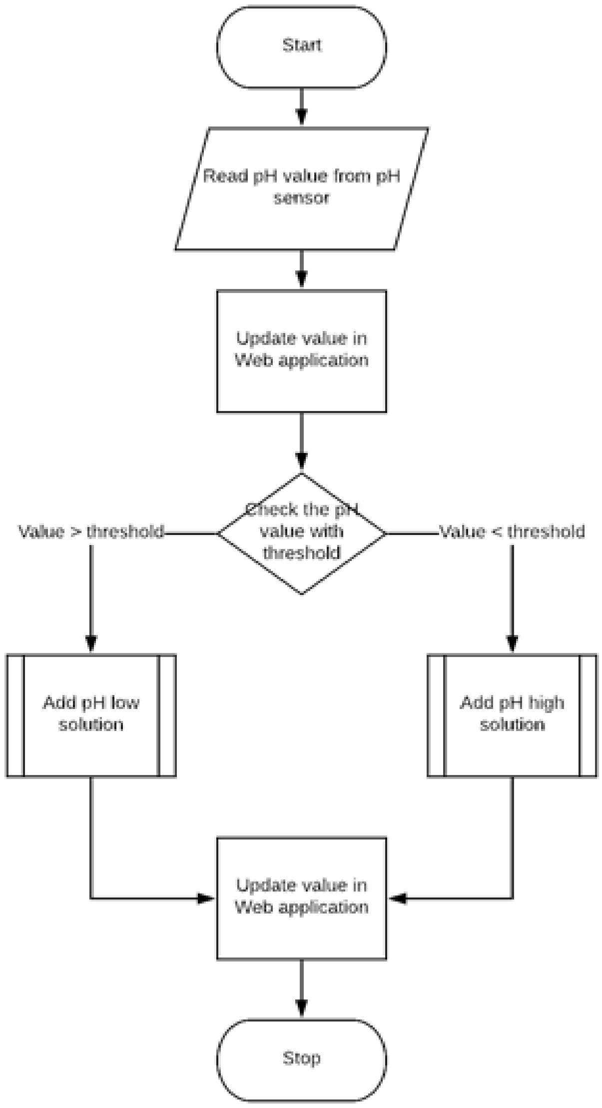

Figure 3: Functional Block Diagram of pH Monitoring Module

B. Controlling brightness by Pulse Width Modulation

Pulse Width Modulation (PWM) is a technique used to encode a message into a pulsating signal. In PWM, the average value of voltage and current fed to the load is effectively controlled by turning the switch ON/OFF between the supply and load at a fast rate. One ON time and one OFF time is called a duty cycle. The current passed on the load is directly proportional to the ON time. Thus the brightness of the LED light is adjusted by varying the ON or OFF time of the duty cycle.

The microcontroller controls the brightness of the Highway lights through PWM based on the inputs from the ultrasonic sensor and LDR. Dynamically varying the brightness of the lights contributes to energy conservation.

V. FUTURE SCOPE

This paper could be extended by replacing the sensors with wireless sensors forming a Wireless Sensor Network (WSN). The ESP 8266 microcontroller can be replaced with Raspberry Pi as it supports an in-built database and is better in terms of computing power. The data from the sensors can be analyzed to obtain valuable analytical information which can be used to further improve the efficiency of the system.

VI. CONCLUSION

The sensor based dynamic highway light dimming system is an innovative energy conservation system. The working principle and automated elements are reliable and fool proof and are expected to minimize energy consumption and thus minimize carbon footprint. The cost of installation can be minimized by integrating various units in a zone. The use of evolving technology with technical excellence will affirmatively lead to the improvement in the efficiency of any engineered system.

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