IOT SYSTEM FOR AEROPONIC CHAMBER TEMPERATUREMONITORING

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Abstract: In recent years, the Internet of Things (IoT) has received much attention in the areas of industry and academia. Currently, IoT technologies are being applied in many fields and is changing lives in many areas such as smart homes, smart cities, smart grids, autonomous cars, and the industrial internet. Howbeit, traditional agriculture is still waiting for many changes to occur in networking technology especially in IoT. Many researchers and engineers are working towards applying IoT technology to traditional agricultural methods. Aeroponics farming is an efficient and effective process for growing plants without using soil. When we apply IoT technology to an aeroponics system, it is expected that there will be many improvements such as decreasing water usage, increasing plant yield, minimizing rate of growth and reducing the workforce. In this paper, we designed and implemented a new automatic aeroponics system using IoT devices. Our system is comprised of three main components: a mobile application, service platform and IoT devices with sensors. The mobile application provides the user a graphical user interface to monitor and adjust the aeroponics system. The service platform is a middleware system that provides information for the mobile application to

store the gathered information from IoT devices using sensors within the aeroponics system. The IoT device uses sensorswithin the aeroponics system to

control each pump and access data. Our work is a new application in the

agricultural industry and is expected to be a promising application that will help the farmer withincreasing productivity in farming and reducing carbon footprint.

Keywords: IoT (Internet of Things), Wireless Sensor Networks, Sensor Data Integration, Smart Farming, Automated Aeroponic System

I.INTRODUCTION

Earth's population is expected to grow in more than two billion people in fourth coming approximately more than a hundred hectares of additional conventional farmland. This product wasdesigned to survive the long journey and extend shelf life in local stores. Good quality and delicious, limited-quantity products are availablefor a few months in a year, so off-season farming doesn't matter. Another issue is that crop yields are highly dependent on the weather. A single poor growing season can cause thousands to starve in many areas of the world.

Aeroponics is the process of growing plants in an air or moist environment without the

use of soil or an aggregate medium (NASA Spinoff, 2006). In aeroponics, plants are grown in an air or mist environment without engaging soils or any aggregate or soil medium (Arunkumar & Manikand, 2011). Aeroponics gives room for easy access to plant roots since it is not planted in any aggregate media (Pagliarulo & Hayden, 2002). The main idea behind the aeroponic greenhouse in intelligent space is full automation, scalability, anytime-anyplace access monitoring, and faultdiagnostic for home or enterprise farming. Aeroponic plants require nutrients from a nutrient- rich water solution that is sprayed onto their dangling roots and lower stem several times an hour. The main advantage of nutrient delivery using aeroponics systems is that the plant is kept in a relatively closed environment, so diseases are not spread rapidly. Another advantage of aeroponics is that suspended plants receive hundred per cent of the available oxygen and carbon dioxide to the root zone, stems, and leaves, thus accelerating growth and reducing rooting times (Martin Pala et al., 2014). Plants grown aeroponically always show proper root hair development due to the highly aerated environment surrounding the root system (Weathers and Zobel, 1991). The growth chamber and fertigation system employed in aeroponics giveroom for complete regulation of the root zone setting, including temperature, humidity, pH, nutrient concentration, mist application frequently and duration.

Plants grown using aeroponics often show signs of accelerated growth and early maturity (Mirza et al., 1998). These abilities have made the technology a popular research tool for studying root growth and nutrient uptake (Barak et al., 1998). The aeroponic technology has also been successfully used for crops that are vegetatively propagated, the most recent being the successful application of technology in the propagation of yams (Maroya et al., 2014). The technique could be a practical solution for commercial farming in the anthropocene where world is facing huge scarcity of freshwater and agricultural land to meet the food demand of 7.6 billion. Moreover, it could be the way forward for sustainable and productive farming technique in space (Udit Sharma et al., 2018). Aeroponics optimizes root aeration, a major factor leading to a yield increase as compared to classical hydroponics (Soffer & Burger, 1988).

II. HISTORY

Carter (1942), who first studied the growth of air culture, identified a method of growing water vapour plants to promote root inspection. Later, Klotz (1944) was the first to discover misted vapour citrus plants in his study of citrus and avocado roots disease research. The term ‘aeroponics’ was coined by F.W Went in 1957 for the air growing process while growing the coffee and tomato crops through the same technique (Udit Sharma et al., 2018). Stoner is considered the father of commercial aeroponics. Stoner’s aeroponic systems are in major developed countries around the world. His aeroponic designs, technology and equipment are widely used at leading agricultural universities worldwide and by commercial growers

III. COMPONENS

1. Node MCU

Node MCU is an open sources firmware and development kits to build IoT products. It includes firmware that run on ESP8266 WiFiSoCand hardware that has an ESP-12 module.

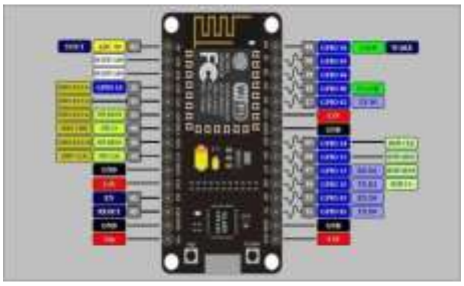

Fig 1: Node MCU

The kit has analog (A0). It also has digital (D0-D8) pins on the board. It even assists serial ports communications such as SPI, UART, I2C etc.

2. SPRAY MISTER

Aeroponics is a method used to cultivate modern-day plants in agriculture. The supply of essential nutrients for plant growth needs no single soil particles. Nevertheless, the roots of plants in aeroponics produce nutrient spray mist ejecting from the nozzles of atomization.

The method of atomization is to break up liquid molecules into fine droplets (Avvaru et al. 2006). Using basic sprinkler- type garden nozzles, the most common aeroponics system uses pressurized water that is sprayed onto the roots. Various atomizers, together with specific spray patterns and orifices, are developed in several disciplines to provide tiny droplets of liquid down to 1 micron. The atomizers are classified as atomizations of a high, medium, and low frequencies (Rajan and Pandit 2001; Lu et al. 2009). Small orifice atomization nozzles may create problems such as nozzle clogging, and cause water supply to stop saturate the air within this range, maintaining humidity levels inside the growth chamber. The selection of nozzles for atomization should be based on growers' requirements. Ultrasonic foggers, whose working frequencies range from 1 to 3 MHz, are expensive and hard to maintain. The foggers require special electrical circuits to power them, so they have very complex structures. Besides, they also influence the nutrient solution's chemical properties. The foggers are suitable for planting indoors. It is more convenient to use the low-pressure nozzles than foggers. These nozzles are cheap and easy to keep, but their quantities of atomization are small.

Fig 2: Spray Mister

3. EC & PH SENSOR

In the aeroponic system, the plant productivity is closely related to nutrient uptake and the EC and pH regulation of the nutrient solution. The EC and pH concentration of the nutrient solution affects the availability of the nutrients to plants . The pH and EC concentra-tions are controlled to prevent barrier growth. Their measurement is essential because the solubility of minerals in acidic, alkaline, and ion concentration of all the species in solutions is different and the solution concentration changes with solubility . The unmonitored EC and pH. concentration of the nutrient solution will quickly lead to a situation where plants cannot absorb the essential nutrients, if not corrected this will eventually lead to harmful plant growth and poor productivity. Thus, the EC and pH concentration of the nutrient solution is a critical parameter to be measured and controlled throughout the plant growth. Moreover, in the conventional aeroponic system, the EC and pH value of the nutrient solution is mostly monitored manually by performing laboratory analysis or using advanced equipment which is a time-consuming process.

For instance, when the EC of the nutrient solution decreased or increased, the control of nutrient solution concentration is mostly achieved by adding more high concentration nutrient solution or the fresh water, respectively, to the nutrient solution to maintain the EC level to the prescribed target range. Similarly, for pH, an acid solution and an alkali solution are used to control the pH fluctuation of the nutrient solution within a specified target range. However, these conventional methods are time-consuming and challenging task for the farmer to maintain the EC and pH value at the desired range accurately. In addition, the EC and pH sensor could be used to deal with the above challenges.

Plant growth responses, photosynthetic rate, stomatal conductance, and transpiration rate were also found to be affected by EC levels. Also, antioxidant defense enzymes such as catalase (CAT), ascorbate peroxidase (APX), peroxidase (POD), glutathione reductase (GR) and monodehydroascorbate reductase (MDHAR) significantly elevated in the leaves and roots ofplantlets at higher EC levels. This increase could reflect a defence response to the cellular damage provoked by higher EC levels in the nutrient solution (Dewir et al., 2005).

4. DHT11-HUMIDITY AND TEMPERATURESENSOR

The DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed).It's fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds. Thus stop clogging the nozzleorifice; the mesh filters are used to prevent clogging of the nozzle. While the larger nozzles with a larger orifice reduce nozzle blockage chances but require high pressure to operate. Selecting the right atomization nozzles is essential for producing the required droplet size. The droplet size ranged from sub-microns to thousands of microns and was characterized in a different rating.

The optimal droplet size range for most plant species within the aeroponics system is between 30 and 100 microns. The smaller droplets

IV.WORKING

We implemented a module to gather each sensors data using IoT devices. Node MCU is one of the IoT devices. In this research, we use Node MCU to gather information (pH balance, temperature, and humidity) from the sensors to control a water pump and dosing pump to add nutrients and water. The gathered information is saved into a database server by sending a SQL query. GPIO pins on the Raspberry PI Zero connects the DHT11 temperature and humidity sensor, Atlas scientific pH probe and EZO Circuit,

water level sensor, LED lights, submersible pump and dosing pumps for the delivery of nutrients. Figure 2 shows the flow chart of the IoT device system.

Fig 3: DHT Module.

Each IoT device gathers sensor data (temperature, humidity, and pH balance) during a certain time. After checking nutrition levels if the nutrition level is below a certain threshold value the Node MCU will trigger a relay. The connected dosing pumps start to work to add nutrition in the aeroponics system. If the nutrition level is over a certain threshold value it will stop adding the nutrients in the aeroponics system. The submersible pump process works the same as the dosing pump process.

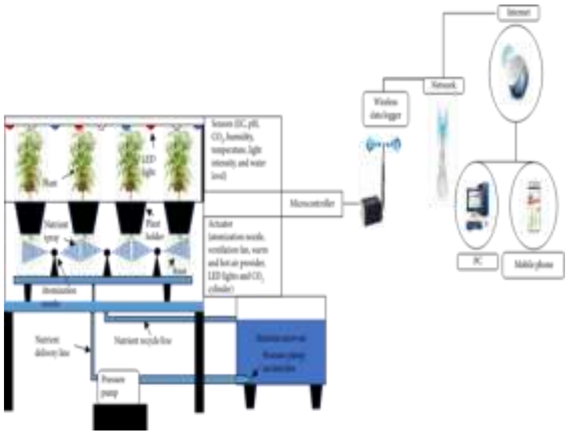

Fig4: Automated Aeroponics System Using IOTDevices

V.SALIENT FEATURES OF AEROPONICS

1. Very Low Water Consumption

Traditional agriculture is the single largest industry taking up the majority of virtual water consumption. On average, one kilogram of vegetables consumes 150 literres of water, more than 90% of which is lost to the environment through leaching and surface evaporation without passing through the transpiration process. Under Aeroponic condition, the water is sprayed as a mist, and also it is collected and recycled and reused.

2. Very Low Mineral Consumption

The mineral composition of plant dry mater, is not more than 5% for the majority of crops. But the utilization efficiency in case of traditional agriculture is very low at around just 15%, and in case of coir media-based hydroponics at around 40%, wasting a considerably large amount of costly nutrients in aeroponics the utilization efficiency is at around 80%, and saving a huge amount in operational expenditure.

3. High Plant Density

Plant density is a function of root competition for water and minerals, foliage competition for sunlight. With water and mineral availability in the root zone are abundant, only the volumetric space for accommodating roots is the limiting factor of plant density as far root zone is concerned. The root zone chamber is of triangular cross-section, crops like cauliflower, cabbage, lettuce and onion can also be grown. This module can accommodate four times more population than that in the flat surface. For vegetables like tomato, eggplant, and beans can accommodate twice that in flat surfaces.

4. Multi Cropping Combination & ThroughoutThe Year Production

Aeroponics system can support all vegetables, both temperate and tropical, severally or individually. The turnaround time for a set of crops like tomato, eggplant, beans, and also for crops like cauliflower,cabbage, lettuce, and onion can be grown in a single unit area.

ADVANTAGES

1. IOT weather mentoring system project using Node MCU is fully automated.

2. It does not require any human attention.
We can get prior alert of weatherconditions

3. The low cost and efforts are less in this system

4. Accuracy is high.

5. Smart way to monitor Environment

6. Efficient

APPLICATIONS

1. Remote sensing
2. Reduction of risk
3. Environment sensing

VI.CONCLUSION

In this paper, we have presented an automated aeroponics system using IoT devices. We designed and implemented an automated aeroponics system to collect each sensor's data in the system. We used a NODE MCU and designed the system to measureand control the environmental factors necessary to reach our optimal agricultural needs. We implemented a mobile application, service platform, and a control module on an IoT device that the user can monitor and control the Aeroponics system remotely. Our proposed system is expected to be a promising application to help farmers increase the production of organic crops in a smart farming system.

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