Smart Hydroponic Farming System

(Product name: GrowGreen)

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***Abstract* — We propose a structure in which each plant will a continuous water supply as well as an artificial light source which would maintain its temperature. The plants would be a part of sensor network, their moisture content, humidity, temperature would be monitored and any deficiency would immediately be resolved. The complete system will be automated as in, the motor and lights are controlled using the signals from sensors.**

Keywords – Hydroponics, agriculture, IoT

This project was carried in partial fulfilment of the course CS F314 - Software Development for Portable Devices, under the guidance of Prof. Sreejith V, at Birla Institute of Technology and Science Pilani, K.K. Birla Goa Campus. This paper was submitted to the Instructor in charge of the course, Prof. Sreejith V, on the 30th April 2018. The hardware components for the project, namely, the NodeMCU, the relays, the portable power sources, and the sensors were arranged by the institute.

I. Introduction

Hydroponics (formed from Greek words *'hydro'* meaning water and *'ponos'* meaning labour) is a method of growing plants without soil, using only mineral nutrient solutions. It is also called as "controlled environment agriculture" (CEA) since raising plants hydroponically requires control of environmental factors such as light intensity and duration, air temperature and humidity, temperature and pH of the solution/medium and mineral nutrients present in it.

The earliest published work on growing terrestrial plants without soil was the 1627 book Sylva Sylvarum or "A Natural History" by Francis Bacon. By the end of that century, it was found that plants in less-pure water sources grew better than plants in distilled water. And by 1842, a list of nine elements believed to be essential for plant growth had been compiled, and the discoveries of German botanists Julius von Sachs and Wilhelm Knop in the years 1859 through 1875, resulted in a development of the technique of soilless cultivation. Growth of terrestrial plants without soil in mineral nutrient solutions was called solution culture. It quickly became a standard research and teaching technique and is still widely used. Solution culture is now considered a type of hydroponics where there is no inert medium.

Cultivating plants in such a controlled environment on a large scale, however, is a very costly endeavor. Thus, maximizing the yield, and optimizing the environment conditions to do so, is essential. This is what we have tried to tackle through our project, and the same is explained in this report.

II. Modules Used

A. Node MCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson, and spiffs. The NodeMCU can be programmed using the Arduino IDE. The IDE is very simple to use and is based on C/C++. It has built-in libraries to interface the NodeMCU as well as sensors to be connected.

The NodeMCU is mainly used to collect data and send it elsewhere (for instance, to a cloud interface for further processing). It is also easy to interface with firebase, and multiple sensors can very easily read values and transmit to firebase. All in all, the NodeMCU plays a central role in data collection and propagation.

B. 5V Relay

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. It needs a 5V power supply to control the signal. To complete the circuit, there are 3 pins on the output side, namely Normally Open,

Normally closed and common. The common pin switches between NO and NC acting as a switch.

C. *Android Studio*

Android Studio is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows, macOS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) as primary IDE for native Android application development. The main program is written in Java language and the layouts are defined in XML. Android Studio supports various libraries that help using available sensors and services on Android based smartphones.

III. Implementation

A. *Experimental Setup*

The setup consists of a 1 meter long 4 inch PVC pipe with two holes at the ends for water inlet and outlet. There are several equidistant holes of about 3.5cm diameter. A 3V-6V submersible water pump is used to pump water from a static source into this setup. The plants are placed in special cups containing cocopeat and cups are placed in this pipe such that the bottom of the cup just touches the water level in the pipe. Another structure is made to hold the light source such that it throws beam of light directly upon plants. The lights and motor are controlled using two channel 5V relay board. The relay is powered using NodeMCU and NodeMCU is power using external power source. The motor is powered by the NodeMCU and lighting system is powered directly from main power supply. The signals for relay are provided from NodeMCU. The soil moisture, temperature and humidity sensors are also connected from NodeMCU to the setup.

B. *Android Application*

An android application was developed with Android Studio to remotely control the setup. The application uses firebase authentication and real-time database to communicate with NodeMCU. The registered users can view the latest readings of soil moisture, temperature, humidity and then control the lights and motor accordingly. The signals are sent through a switch to firebase, which are then retrieved by NodeMCU and relay is activated. The control panel lets user control the light and water motor remotely through internet.

C. Automation

As explained in the application interface above, there are two switches present to power the motor and lighting system respectively. The application communicates with the NodeMCU through firebase. The sensor values are also read every 2 seconds through NodeMCU and sent to application via firebase server.

IV. Future Work

Hydroponic farming is an emerging farming technique that is bound to yield good results. Taking inspiration from techniques around the world, this project too can be extended. The current problem hydroponic farming faces is the immense cost it incurs. A lot of care is needed for the plants and the conditions need to be checked every few hours, else the loss might be catastrophic. To overcome these issues, IoT can provide a low-cost solution. The solution is three-fold:

1) *Further Automation:* Using sensors for monitoring oxygen and carbon dioxide values can maintain a healthy environment for the plants effectively. External factors like lighting can be controlled to match the photosynthesis and respiration cycle for plants. Water pH and mineral values are also important aspect of plant growth that can be monitored for effective growth.
2) *Learning:* In time, using effective deep learning algorithms, the sensor-actuator model can be trained to optimize and control the environment conditions for multiple plant species, irrespective of any momentary stimulus. This can help analyse the optimal conditions for plant growth.
3) Cost effectiveness: The present systems are very costly and lack the automation. Some biochemical research can be done to prepare solution of necessary mineral and insecticides that can aid plant growth. The production on bigger scale will reduce the prices and automation will reduce the necessity of physical presence.

References

A number of modules were used for our project, and the configurations and documentations for the same were constantly referred to. The same are listed below.

[1] Arduino IDE : https://www.arduino.cc/en/Main/Software

[2] NodeMCU board pin configuration and documentation [Online]: https://www.espressif.com/en/products/hardware/esp8266ex/overview

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[4] Android App Development Kit : https://developer.android.com/studio/index.html

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