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Indoor Plant Monitoring System Using Node MCU and Deep Learning

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***Abstract*— IoT allows objects to be sensed and controlled remotely across existing network infrastructure , creating opportunities for more direct integration between the physical world and computer – based systems , and resulting in improved efficiency , accuracy and economic benefit. As water supplies become scarce and polluted, there is an urgent need to irrigate more efficiently in order to optimize water use to support green environment. This project explains a smart Houseplant Watering and Monitoring system that monitors and tracks environmental conditions, helping the plants thrive. The sensors gather and analyze data about changing weather and soil moisture conditions and then connects to the user's Android phone with timely alerts.**

Indoor plant monitoring system is a smart Houseplant Watering and Monitoring system that monitors and tracks environmental conditions, helping the plants thrive. The Garden Sensors gather and analyze data about changing weather and soil moisture conditions and then connects to the user's Android phone with timely alerts. Also, the system includes an android application which runs on an android devices which can be used to monitor the plant's conditions at user's workplace. It continuously monitors the conditions and alerts the user to the changes that require immediate action. Unlike pre-set sprinklers, the Greeves Water Valve automatically controls the existing water system based on data collected by the Garden Sensor and adapts to every change in the plant's requirements. The paper describes the architecture and methodology used to integrate different platforms together to develop a working system using Cloud Computing. It integrates Android, Node MCU, Deep learning module (AlexNet) and firebase Cloud together to work in tandem making the system achieve its set goals.

Keywords— Node MCU, Soil Moisture Sensor, Mini-DC Pump, AlexNet model, Humidity Sensor, Temperature Sensor, Deep Learning, AlexNet Module, Firebase Cloud, MIT app inventor, AI chatbot.

I. INTRODUCTION

The perspective for developing this project is to make the managing of plants easy for the costumer using IOT and machine learning. In this scenario manpower will bereduced as there is no need for the customer to manually keep on checking the plants health. This will also save time of the customer. As customers will interact with the AI chatbot he or she can clear all their doubts and also automatically water the plant if moisture in the soil is less. The customer interacts with the android application and the sensors fixed aroundthe plants will update the current condition of the plants environment. .The sensors obtain ambient temperature, ambient humidity, soil moisture, and illuminance it to the cloud which is then displayed on the UI on the user android device. User interface basically interacts with the user and allows the user to view different aspects such as moisture condition , temperature , humidity of the plants environment . The user interface also provides option to add more than one plant and also to water the plants by one click button on app. The pre-trained AlexNet model used in this study primarily consist of 5 convolutional layers (conv layers) and 3 fully connected layers. Here the user can check whether the plant is suffering from the disease by clicking a pic of the plant's leaf and adding it to the trained model. In our project The Indoor Plant Monitoring System we have it developed as a IOT application. The system can be accessed from the android devices. To simplify the user interface, the software will also provide user manuals that will guide the customer to access the online portal.

The main objective of the proposed paper is to use the INTERNET OF THINGS to achieve the following goals:

- No need for the customer to manually keep on checking the plants health.
- Power consumption of a wireless sensor network should be less so that it can be used for a long period of time.
- Precision in providing the environmental condition of the plant.
- Automatically water the plants when the owner is not present.
- To know the health condition of the plant using the Alexnet model.

II. LITERATURE SURVEY

Plant provides us with almost all the basic needs for survival but we are unable to provide plant with its basic needs like water, non-polluted oxygen and as a result plants are unable to survive. .In the paper by Satyam Kumar Sinha, Bhupendra Singh and Aashish Kumar Gupta[1] in 2017 on IOT based smart garden monitoring system which sense the requirement of the plant and provide it with water as the soil loses its moisture has so drawbacks where the requirement may have been fulfilled by the system for survival but didn't detect the other reasons like disease ,climate changes which are equally important factors which should be prevented for the plants survival. Devika CM in 2017[2] used a simple Arduino to introduce automation in watering plants. The drawback of it being that it was restricted in terms of its resource sharing as the information could not be accessed globally.

Today, we have much better options other than GSM such as cloud computing [3] which will be much beneficial in maintaining a database and uploading each and every real time updates. Stesel in 2018[4] used Arduino Uno and Arduino Nano respectively along with the Wi-Fi module to achieve this. However, the complexity of the circuit could be reduced by using a standalone application of Wi-Fi module.

The latest advances in Neural Networks (NN) have produced complex classifiers without the need to analytically define the discriminating function. The paper by P. S. Georgantopoulos, C.Constantinopoulos and D. Kosmopoulos[5] detects tomato disease. So the idea of creating a module using AlexNet comprising of all the plant diseases was inspired from this paper.

III. SYSTEM ARCHITECTURE

The Fig. 1 shown below depicts the system architecture of the proposed project.

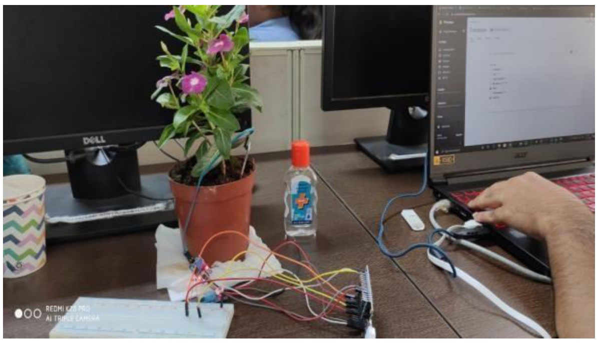

Fig. 1: Prototype of Indoor Plant Monitoring System Using Node MCU And Deep Learning

Using the system shown above we are able to collect all the data related to soil moisture, temperature of the environment around the plant and this data was then pushed to the firebase cloud. Then this data was use to take decision to water the plant our to give extra light automatic. The prototype comprises of the Node MCU interfaced with relay module. Also, the dht11 and soil moisture sensor have been connected to the Node MCU which serves as the central unit for the entire system. The mini dc pump receives power supply from a 12V dc adapter and the relay is given a power supply of 5V. The technical block diagram of the circuitry has been depicted in Fig. 2.

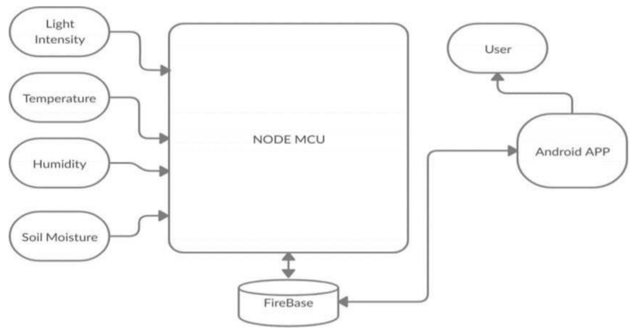

Fig. 2: Technical Block Diagram

1. NodeMCU

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications[9]. It includes firmware that runs on the ESP8266 Wi- Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The mainreason to select this is because it is inexpensive and has an inbuilt Wi-Fi module[10]. It is like Arduino so can be coded using Arduino IDE software. It contains 10 General Purpose Input/output pins for interfacing with devices. Atypical NodeMCU along with its pin numbering is shown in Fig. 3.

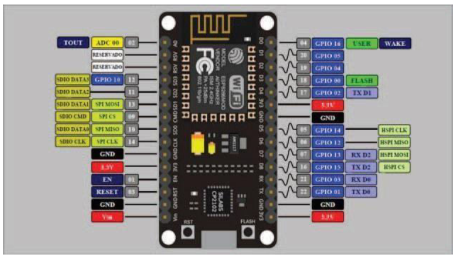

Fig 3: Node MCU

2. DHT 11

The dht11 sensor, a combination of temperature and humidity sensor generally gives digital or analog output[11]. It includes information about the temperature around the plant whether it requires more sunlight or not as well as It deals with the humidity present in the environment around the plant. The electrical resistance in between the two electrodes is used to detect the water vapor. The electrode along with the substrate which is responsible for holding moisture when in contact with the surface acts as the humidity sensing component. The substrate releases ion which results in a rise in conductivity between the electrodes as soon aswater vapor is absorbed by it. The result calibrated by the dht11 sensor is quite accurate. The DHT11 sensor has a lot of applications owing to its small size and lower power, also it has a wide range for the transmission of the signal which is up to 20 m. The product which we have used is a 4 pin single row pin package thereby making it appropriate for the breadboard connections. The dht11 sensor is available in two alternatives, either the sensor or the module [12]. Fig. 4 shows DHT 11 sensor.

Specification:

- Temperature range: 0 to 50° Cerror of + 2° C.
- Humidity: 20-90% RH + 5% RH
- Interface: digital

Fig 4: DHT 11

3. *Soil Moisture Sensor*

Soil Moisture Sensor is a simple breakout for measuring the moisture in soil and similar materials. The soil moisture sensor is pretty straight forward to use. The two large exposed pads function as probes for the sensor, together acting as a variable resistor. The more water that is in the soil means the better the conductivity between the pads will be and will result in a lower resistance, and a higher SIG out[13]. It is generally used in greenhouses to control water supply and other enhanced bottle Biology experiments to monitor the content of water in the soil. Fig. 5 shows a typical soil moisture sensor and the specifications of the same has been mentioned below.

Specifications:

- Working voltage: 5V
- Working current: <20 mA
- Interface: Analog
- Working Temperature: 10°C~30°C

Fig 5: Soil Moisture Sensor

4. *LDR sensor*

The light sensor is a passive devices that convert this "light energy" whether visible or in the infra-red parts of the spectrum into an electrical signal output. Light sensors are more commonly known as "Photoelectric Devices" or "Photo Sensors" because the convert light energy (photons) into electricity (electrons)[14]. This sensor in this project is used to detect the intensity of the light (sunlight) falling near the plant so if the sunlight found to be less can be compromised by the artificial light provided by the UV bulb so that plant can complete its nutrition required. Fig. 6 shows a LDR sensor and also its specifications are mentionbelow.

Specifications:

- Working voltage: 3.3V
- Max. resistance @ 10lux: 4.5kΩ
- Dark resistance after 1sec: 0.03MΩ

Fig 6: LDR Sensor

5. *Mini-DC Pump*

A pump is basically a device which uses mechanical action to transfer fluid (liquids). The mechanism used in a pump is mainly reciprocating or rotary and in order to do this mechanical work, they also consume some energy. Pumps are available in varying sizes ranging from smaller pumps used for medical purposes to larger ones used in industries . Fig. 7 depicts the Mini-DC Pump which has been used. Here we have used a mini dc pump which runs on 12 volt dc supply. Pumps can be operated manually or using electricity. Some are also operated using engines and power generated from the wind.

Fig 7: Mini-DC pump

6. *Relay*

Inside a relay, there is a core with copper wire wound around it (the coil). Under normal conditions, the switch(armature) remains in contact with the normally closed (NC) terminal. But when voltage is applied through the coil, electromagnetic field is generated and the coil starts to act as a magnet, pulling the armature towards itself to the normally open terminally (NO). That's all there is to relays at the most basic level. Other than that there are many other types of relays, such as solid state and thermal relays, with different operating mechanisms, but all of them have the same common purpose. Here this part is use to control the mini dc pump for automatically watering plant and the flow is controlled by relay. In general, control circuit handling smaller currents are switched by relays. In addition, with the help of amplification even larger voltage and amperes can be controlled by it[16]. Relay used in the project is shown below in Fig. 8.

Fig. 8: Relay

IV. SOFTWARE USED

a) Arduino IDE Software

Arduino is basically a combination of hardware and software which works as an Open source (easily accessible by people over the internet). The Hardware part comprises a circuit board embedded with a microcontroller which is Programmable whereas the software is an IDE where we can write and upload code [6]. The languages supported by it are C and C++ using special rules of coding structure. As the Arduino IDE is compatible with a number of different circuit boards, here we have integrated the IDE with NodeMCU board.

b) MIT App Inventor

MIT App Inventor is a web application integrated development environment originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT)[7]. It allows newcomers to computer programming to create application software(apps) for two operating systems (OS): Android and iOS. It uses a graphical user interface (GUI) very similar to the programming languages Scratch (programming language) and the Star Logo, which allows users to drag and drop visual objects to create an application that can run on android devices, while a App-Inventor Companion (The program that allows the app to run and debug on) that works on iOS running devices are still under development. In creating App Inventor, Google drew upon significant prior research in educational computing, and work done within Google on online development environments.

c) Firebase (Cloud)

Firebase is a Backend-as-a-Service (Baas). It provides developers with a variety of tools and services to help them develop quality apps, grow their user base, and earn profit. It is built on Google's infrastructure[17]. Firebase is categorized as a NoSQL database program, which stores data in JSON-like documents. Here firebase was used to receive the data from the Node MCU who collected the data from various sensors and was displayed on the mobile application. The command like for e.g. watering the plant, turning UV light on etc are automated from here.

d) AI Chatbot:

An AI Chatbot is integrated with the android application which answers all the queried of the user and also suggest the solution for any disease that has happened to the plant. It also allowed to give command such as turn on the pump or to turn on lights etc. It is been created using google voice template[8].

V. ALEXNET MODEL

The pre-trained AlexNet model used in this study primarily consist of 5 convolutional layers (conv layers) and 3 fully connected layers[18]. Here the user can check whether the plant is suffering from the disease by clicking a pic of the plant's leaf and adding it to the trained model. This model performed with the accuracy of 96%. The model was integrated with the android application created using MIT app inventor so that the customer or the user can click the picture with his smartphone and can detect the disease and also ask the app for suggestion to cure it[19]. The architecture is been shown in fig. 9 below.

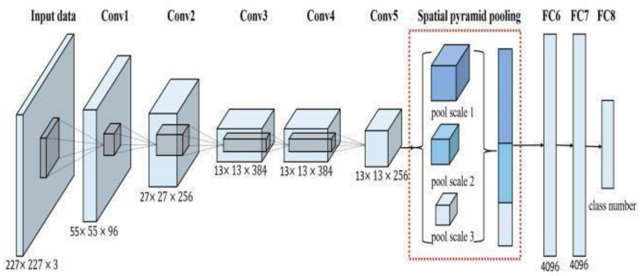

Fig. 9: Architecture of the AlexNet model; trained on the plant leaves dataset

VI. IMPLEMENTATION OF PROPOSED SYSTEM

First the sensors which are placed around the plant collect the data with respect to temperature, humidity, soil moisture and the light intensity. Now this data is been sent to the Node MCU which is acting as the central processing unit. Then this data is been pushed to the firebase (cloud). The data from the cloud is then displayed on the users phone via the application that is been created using MIT app inventor. The data is been updated on real time basis i.e. every second. From the application user can give commands to water the plant from any where in the world or else the water will be given to the plant automatically using relay.

In order to achieve this, a relay module is interfaced to Node MCU board at the receiver end while on the transmitter end, a set point on the soil moisture sensor is considered. If the moisture of the soil falls below the set-point, the relay switches on and allows the mini-dc pump to conduct and supply water to the plant fields. Once the required moisture level is reached, the soil moisture sends the signal to the relay module via Node MCU .The relay switches off and thus switching off the mini –dc pump.

Fig. 10 shows the flow chart diagram depicting the methodology.

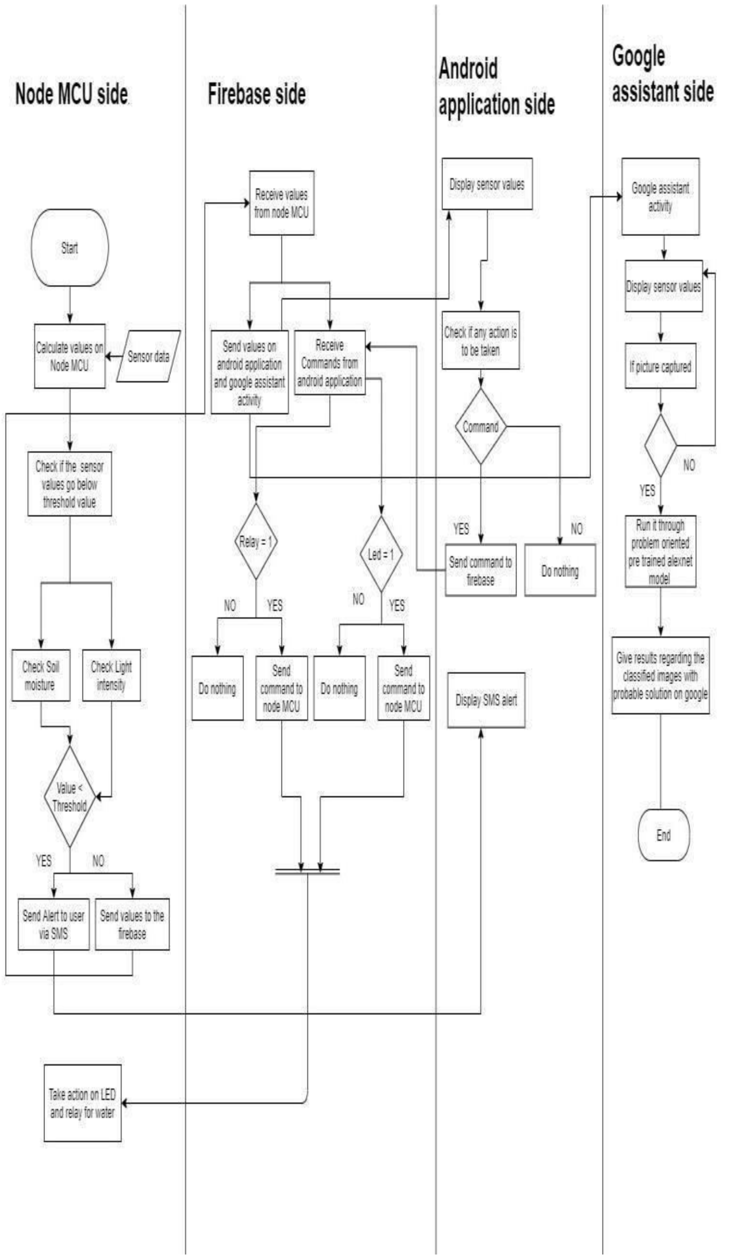

Fig. 10: Flowchart of whole process

VII. RESULT OF IMPLEMENTATION

Experimental Results have been obtained after the successful implementation of the circuitry. Fig. 11 shows the output sensed by the sensors on the application developed on the MIT app inventor which was then installed on the Smartphone of the user. It monitors the humidity, temperature, soil moisture and the light intensity. The screenshots of the app as well as of the image of the AlexNode output of the disease have been shown in order to validate the results obtained.

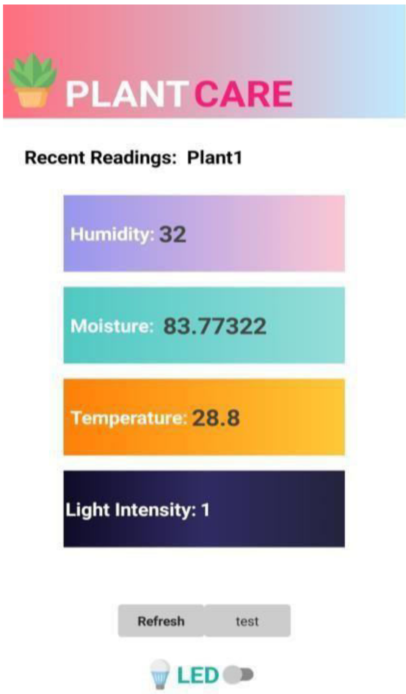

Fig 11: Output of Application on user's smartphone

Fig. 12 shows the output provided by the AlexNet module related to the plant disease which was obtained by just clicking the photo of the plant's leaf and running it though the model which gave accuracy of 96%.

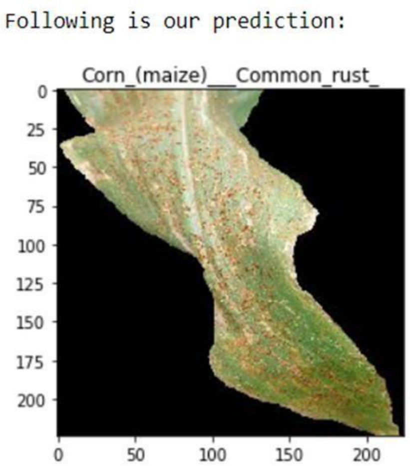

Fig.12: Output of AlexNet model; trained on the plantleaves dataset

Fig. 13 are the screenshots of the chatbot which wascreated using the templates of google voice giving the real time information of the enviorment around plant by using the command " How's my garden doing"[20]. It also provides the suggestion to cure related to any plant disease by searching the accurate data from the internet.

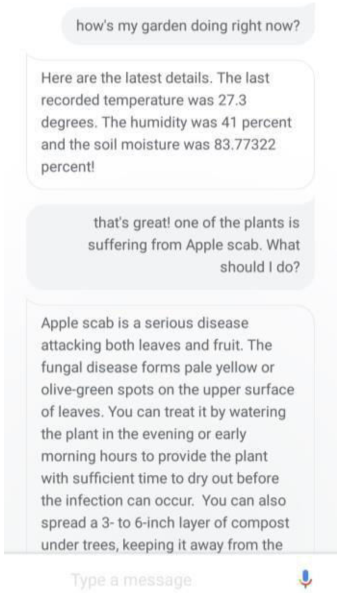

Fig. 13: Screenshots of Chatbot

VIII. Conclusion

The basic ideas which were intended to be implemented in the project i.e. Indoor plant monitoring system consisting various operations like knowing plants health , watering the plant, checking plants health etc. was carried out successfully. This system reduces human labour, work load and is also time efficient. We have tested the system and carefully and closely observed the results achieved thereafter. All the hardware components have been integrated to develop the system. The working of each and every module has been reasoned out with utter carefulness and they have been placed in such a way that they contribute towards getting the best results from the system..Hence, a working project is successfully designed and implemented giving the desired outputs.

IX. FUTURE SCOPE

The scope of Indoor Plant Monitoring System using IoT is vast. The main aim of this system is to obtain ambient temperature, ambient humidity, soil moisture, and illuminance from a set of sensors. The Indoor Plant Monitoring System using IoT will also provide recommendation to how to take care of plants , find out which disease it has by using AlexNet model; trained on the plant leaves dataset and also water the plant using the android app . The scope of this project is never ending because every person in today's fast world will require a helping hand to look after the plant and provide status of plants health even if he or she is not present at the plant location. This same idea can be further used on a large scale for agricultural purpose on a huge acers of land which will eventually help farmers and reduce their job.

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