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IoT Based Smart Agriculture Monitoring and Control

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Abstract— The **Internet of Things (IoT) is the technology developing the agriculture industry and enable it to deal with various challenges during farming. Agriculture is the backbone of Pakistan's economy. To increase the productivity and environmental impact of agriculture this IoT based agriculture has great advantages over traditional farming.[3] These methods give uninterrupted monitoring and automation for proper operation.**

IoT will help to increase productivity, less consumption of water, and reduces human efforts. [1]

IoT utilization will help in different things like aid in predicting crop yield, different parameters i.e., soil temperature, moisture, humidity, water level, and proper timing of crop to be delivered to plug, which will help to increase the crop yield.

Agriculture has a vital role in the developing economy. Despite this, the development of Agriculture technology is very less and negligible. In Pakistan, all Farmers are using conventional methods for farming, the developed technologies are either expensive or very complex to use by farmers. [1]

This paper presents a study to solve common issues and provide a smart agriculture system at an affordable cost. The study consists of the framework on sensing soil moisture, temperature, and humidity which enables to predict and observe the irrigation requirement of the agriculture field. These techniques provide information about needed parameters for obtaining the maximum product.[4] The proposed system is controlled by a microcontroller that is NODE MCU along this decision making is also carried out through it. Users can analyze and observe the field through Blank App notification.[2] The system ensures the good health of the crop.

***Index Terms*— IoT technology, automatic irrigation, Node MCU, Water Pump, Motor driver, Moisture Sensors, DHT11 Sensor**

I. INTRODUCTION

IoT technology can interrelate different devices such as mechanical and digital machines, computing devices, human or any other living thing, objects that can sense for collecting the required data around the world, and then by using the internet it shares the data for processed and utilization for the various amazing purposes.[9] IoT works in real-time and very quickly is becoming reality. IoT technology is mainly progressed examination and mechanical works that use organizing, collecting, detecting, enormous information, and man-made consciousness innovation to send all framework for an administration.[7] We can observe the IoT around us as everything is getting connected to the internet and technologies are getting more smarter day by day from smartphones to smart cars. IoT is basically to extend the power of the internet beyond just smart mobiles and laptops.[6]

IoT Technology key benefits:

1. Efficiently Utilization of all different Resources
2. Reduction of Human Efforts
3. Efficient use of time
4. Real-time Data Collection[9]

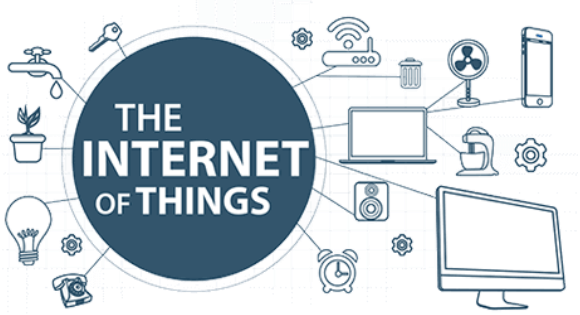

Fig. 1. IoT Technology

Agriculture is the backbone of the economy as well as for living purposes.[5] Agriculture always remains an emerging field at all times. Undoubtedly agriculture is the largest livelihood provider in Pakistan and people from all around the world depend on agriculture for their living. It is also the source of employment opportunities. There is a great need to work on the agriculture sector as the population is increased day by day and with that increase, sources are also decreased.[4] Over the decade, with the help of the latest technologies rapid improvement in the infrastructure was made in various industries. Unfortunately, development in the agriculture sector is negligible many farmers are still using traditional methods which results in a low yield of the crop. As IoT technology and automation had been introduced and human beings had been replaced with robotic types of machinery, production has been increased and human efforts are reduced.[3]

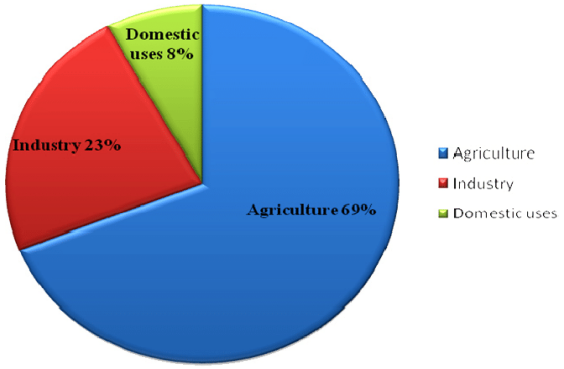

Figure. 2. Economical Structure of Pakistan

Hence there is a great need to implement such technologies in the agriculture sector.

This proposed system is based on IoT technology with several different sensors and an automatic watering system.[9] The main benefit of the system is its very lost and friendly interface. This system is designed for non-technical background people so that they cannot find it hard to use it. The software part and reading interface of the system is also very easy to analyze and data processing of the system.

The basic need for an Automatic Irrigation

(1) Using resources efficiently and Saving of energy as well as human efforts. [10]

(2) Complexity is very low, and the system can be easily installed on the field.

(3) Automatic watering will enable less consumption of water.

(4) Valves and motor drivers are used in automated irrigation and watering systems to turn on/off the motor.

(5) water pump or motor can be easily operated with the soil moisture sensor-based controller and by which it can get rid of workers monitoring or operation of irrigation system.[4]

(6) light controlling through the IoT will also help the farmers to make a good environment for the crop. [10]

This paper, therefore, presents a system bases on IoT technology that is beneficial in controlling and monitoring agriculture in real-time that makes the system very easy and flexible to the farmers.[8]

Figure. 3. Smart Agriculture

II. METHODOLOGY

The system is purely designed for farmers to handle their agricultural farms in limited resources. Agriculture is a growing field, therefore it requires several advanced technologies, and they are implemented in this field, such as IoT and Cloud so that it can be monitored and operated efficiently from a remote area in real-time. [6] Humidity sensor, temperature sensor, ultrasonic sensor as well as the moisture sensor.[1] Gathering of data through IoT technology and control according to the data shared in real-time is a great way to maximize the growth and minimize the time and efforts the purposed system is based on IoT features and sensors.[7]

To build a smart irrigation control and monitoring system. It helps in short time decision making situations for the smart irrigation purpose.

An IoT technology is very much efficient and accurate in agricultural management which gives farmers to face many regular problems and challenges they face.[9] An IoT system has many advantages in agriculture farms and management, which deals with many issues such as detection of moisture, temperature level detection, indications of water level, monitoring of crop growth, humidity detections, and many other important parameters. The proposed system enables the users a better and smarter irrigation system with the help of a microcontroller and different sensors that communicate with the microcontroller and gives data to the user in any remote area in real-time.

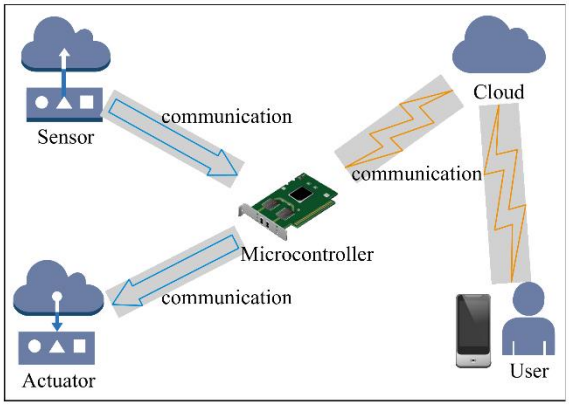

Figure. 4. IoT Structure

This model only uses a single microcontroller, which is NodeMCU with IoT build in, for the purpose to acquire data and readings from all different sensors. For the measurement of different parameters, the sensors which are used in this system are the YL-69 soil moisture detector, humidity, and temperature sensor DTH11. These sensors are interconnected with the microcontroller to acquire the readings and the microcontroller is linked with IoT which sends data to the user with the help of a Wi-Fi module which is NODE MCU in this system.[3] The whole system is directly connected to the internet for visualization and monitoring of data via phone.

IoT is nothing more than a computer idea where everyday objects with integrated hardware/devices are attached to a network or merely online.[2] Blynk is a platform for controlling microcontroller.

PROPOSED SYSTEM:

Given block, Diagram shows the working model. This system has NODE MCU as a microcontroller which also plays a function of the WIFI module and creates a communication channel with the system and mobile application. Through mobile application user can access the data and readings along this user can control the system according to the requirements.

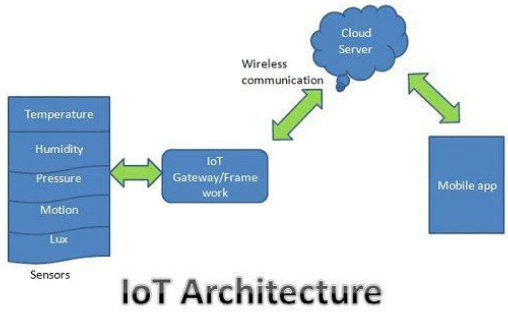

Figure. 5. IoT Architecture

This system can be divided into two main parts, one is controlling the irrigation process using NodeMCU based on soil moisture value from soil moisture sensor and the second part is publishing the data to the mobile application for users to monitor the data.[8]

A. Microcontroller NODE MCU:

In this system, NodeMCU is used as a microcontroller. It controls the whole system from android application to sensors, it also creates a channel between all working components. It is shown from the diagram that all sensors and the water pump is directly connected with the microcontroller NODE MCU.[5] Node MCU is programmed in C++ language. The microcontroller which is NodeMCU is the open-source board that is widely used as ESP8266 -12E with Wi-Fi features.[6] This is easily programmed through Arduino IDE with the powerful programming language. It includes all features of the WIFI and the microcontroller.

Figure. 6. NODE MCU 1.0

This system has a microcontroller which is NodeMCU is using a 9V supply. A microcontroller is unable to directly supply power to the water pump due to the current is too low and has to be taken from another power source.[4] The system has the soil moisture sensor, along with this one more sensor to monitor the humidity and temperature. Temperature and humidity sensors enable the users to monitor and study humidity and environment temperature which affect the growth of the plants. [7]

The data and readings uploaded by the microcontroller NODE MCU can be access from anywhere on the mobile app in real-time. Along with, the exact condition of the environment by implementing different sensors compare to those traditional farming.[9] Besides accessing the data through the online platform, users also can monitor the data through the mobile application from anywhere. Other than that the user also can override the system when pushed the manual button. This manual button will stop the system in case anything happened but will give the user permission for the manual pump button on the apps.[5] This manual pump is for the specific plant that will need more water than its usual needs. When the pump is on it will give notification to the user so that the user will be alerted.

B. Soil Moisture:

The soil moisture sensor which is used in this system is **YL-69**. This sensor measures water content in specified soil. This sensor is very simple to use rather than a direct gravimetric measurement because direct measurement has some errors and it is a bit tough to use.[3] YL-69 moisture sensor gives readings of the soil moisture by using some other special electrical properties like resistance and dielectric constant.

When moisture of soil goes below the threshold value it gives notifications in the mobile app about current moisture reading.[6] It also notifies the user about the high value of the moisture level in the soil so that the user can take steps accordingly all of it happens in real-time and can be monitored and controlled from the remote area.[1]

Soil Moisture Sensor (YL-69) Functional Description:

This sensor has Two copper leads presented which act as probes for the sensor. These two probes of the sensor are directly inserted into the soil where we are interested to find the content of moisture. There are three different conditions of the soil.

Dry condition: **-** this is the soil condition with no water and zero moisture. When probes of the soil moisture sensor are inserted into the dry soil. Due to no conduction path, the circuit becomes open and the emitter output voltage is indicated between 0-0.5 volts.[6]

Optimum condition- this is the Soil with some moisture and content of water in it.[4] water provides the conduction path to the sensor probes and it detects output voltage with the range 1.9-3.4 volts.

Excess water condition- this soil has an excess of water and high readings of soil moisture content. In terms of voltage, it has an output voltage greater than 4.2 volts. This is steady-state.[6]

YL-69 moisture sensor shown in the figure:

Figure. 7. YL-69 Moisture Sensor

Working of Sensor:

There are two probes in this sensor that are inserted into specified soil.[3] When a circuit is kept close current is passed through probes, the soil with low moisture level has a low resistance and the soil which has high-value pass high current. By using this property soil moisture level is measured.

C. DHT11 (Temperature and Humidity Sensor):

For soil temperature and relative humidity readings, a single sensor is used in this system which worked for both data and readings.[4] DHT11 is the Temperature and humidity sensor that is used in this system.

The DHT11 sensor is very proficient with high accuracy in calculating the readings and monitoring these values anytime from anywhere. DHT11 has a thermal resistor and to gauge the pressure of the atmosphere a capacitive humidity sensor is used.[3] DHT11 Sensor is very low in cost with high accuracy in readings and multiple functions, it also uses very low operating energy.[10]

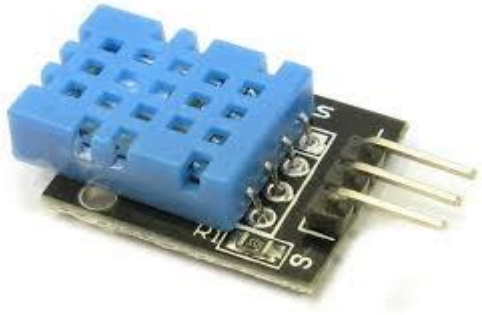

Figure. 8. DHT11 Sensor

After sensing the current values of the humidity and temperature these values are sent to the microcontroller NODEMCU which directly transfer to the Mobile app which displays the readings to the users. The medium through the transferring in data is IoT and based on the Wi-Fi module.[8] This is very simple for everyone to use but along this, it also requires very careful timing to acquire the readings and data.

D. Automatic Watering:

The water pump which is used in this system is a DC *12V* submersible *water pump*. This water pump is very useful in making an automatic watering system for any plant.[7] In this system for controlling the watering of the plant water pump is used so that users can turn on/off the water pump from a remote area with just a single click on their mobile app.[10] Users can monitor the soil moisture value and if it is low than the threshold value user can turn on the water pump and start watering to the plant in real-time. The water pump is also connected with the microcontroller so that it may have access to the system in the mobile app. [5]

Figure. 9. Water Pump

E. Motor Driver:

In this system, a single motor driver is also used. The function of the motor driver in this system to control the water pump in the automatic watering. The motor driver gives the signal to the pump to supply water.[10] A motor driver is a device that makes the motor move as per the given instructions from the users. It controls the motor and, in this system, it controls the water pump for automatic watering purposes.[9]

Figure. 10. Motor Driver

Data Proceedings:

Step 1:

Working of This model starts from different sensors they sense their respective readings by the specific properties of the sensors.[5] Sensors obtain readings at every instant.

Step 2:

After these sensors send these readings to the microcontroller which is NODE MCU in this model.[3] Sensors are directly connected to the microcontroller.

Step 3:

After acquiring data from the sensor's microcontroller processes the data, then the microcontroller sends it to the IoT platform which is Wi-Fi in this model. Data travel through IoT channel.[9]

Step 4:

Data that is sent by the microcontroller in the IoT platform will be received in the Blynk App to display the readings.[2] Blynk App displays the readings at every instant which is sent by the microcontroller through the IoT platform. Now users can have access to the data in the mobile app.

Step 5:

After having access to the different parameters' readings like soil moisture, temperature, and humidity users can take requires steps in real-time which ensures high efficiency and accuracy in the working model.[3] This system provides high growth agriculture with control and monitor.

Step 6:

The user also has control through the Blynk app so different parameters that are below or up to the threshold points can be

fixed. Automatic watering and light control are the main part. the water pump can be turned on/off as per the need. [9]

III. CIRCUIT DIAGRAM

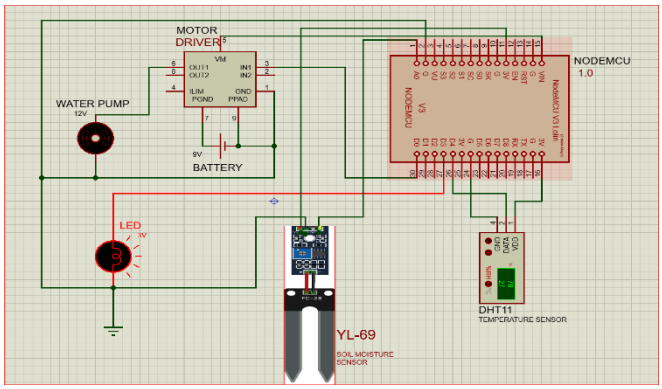

Figure.11. Circuit Diagram

IV. SOFTWARE INTERFACE

The software part of the proposed system is BLYNK App which is directly connected with the microcontroller which NODE MCU. NODE MCU works as a Wi-Fi module. Blynk app has designed a new project in it named IoT Irrigation in which three-parameter gauges are created which are Soil Moisture. Temperature and humidity.[7] Two bottoms are also has been created for the water pump and light. The water pump and light can be controlled and turn on/off by these buttons.

Figure. 12. The software interface of System

V. RESULTS AND DISCUSSION

The system has been divided into two parts, one is monitoring with all three sensors and the second is the automation of watering and light.[9] The system can be easily monitored by the Blynk app and same it can be controlled through it.

Figure. 13. The interface of the Running System

The results have been taken after assembling the system with all the components as well as compiling and troubleshooting the codes on the ESP8266 module through Arduino IDE software and commands followed by Wi-Fi connections give arbitrary values and graphs.

TABLE I: Values of different Parameters

NO	Parameter	Morning Time	Afternoon Time(full Sun Light)	Night Time
1.	Soil Moisture (%)	56	54	58
2.	Soil Temperature(oC)	29.12	36	22
3.	Relative Humidity(%)	66	65	66

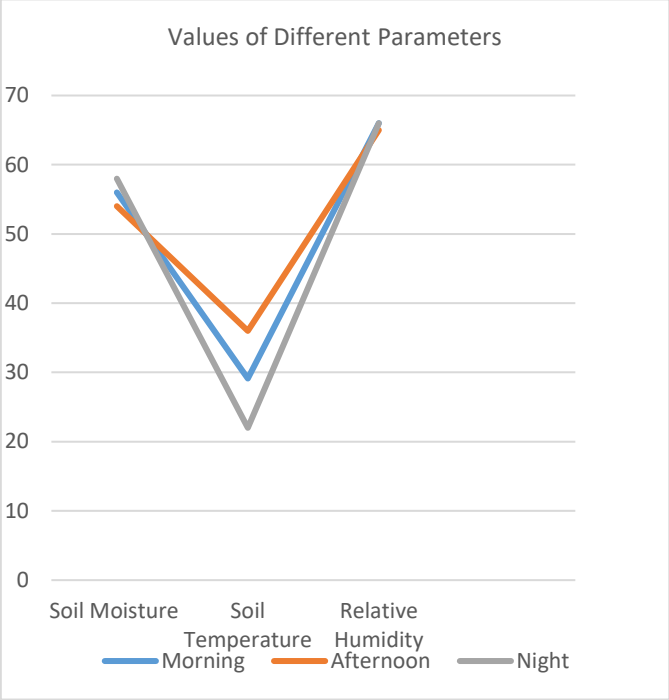

Figure. 14. Graph of Table I

TABLE II: Value of Soil Moisture in Different Soil conditions.

NO	Parameter	Dry Soil	Optimum Condition	Excess of water
1.	Soil Moisture (%)	9	67	80
2.	Soil Temperature(oC)	28.7	26	24
3.	Relative Humidity(%)	66	64	65

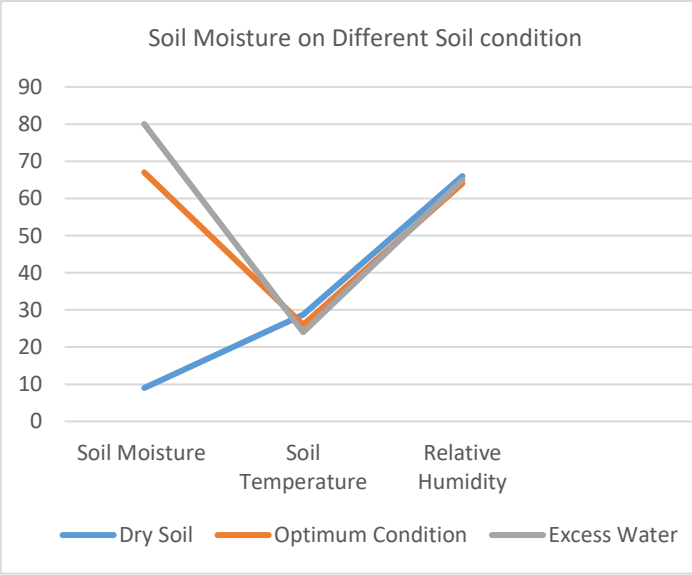

Figure. 15. Graph of Table II.

TABLE III: Comparison of the predicted and actual value of soil moisture

Day	Actual value of Soil Moisture (%)	The predicted value of soil moisture %	Difference between (Actual-Predicted)
Day1	53	56.244	-3.247
Day2	52	52.10	-1.47
Day3	54	53.98	0.016
Day4	56	56.73	-0.73
Day5	61	60.47	0.52

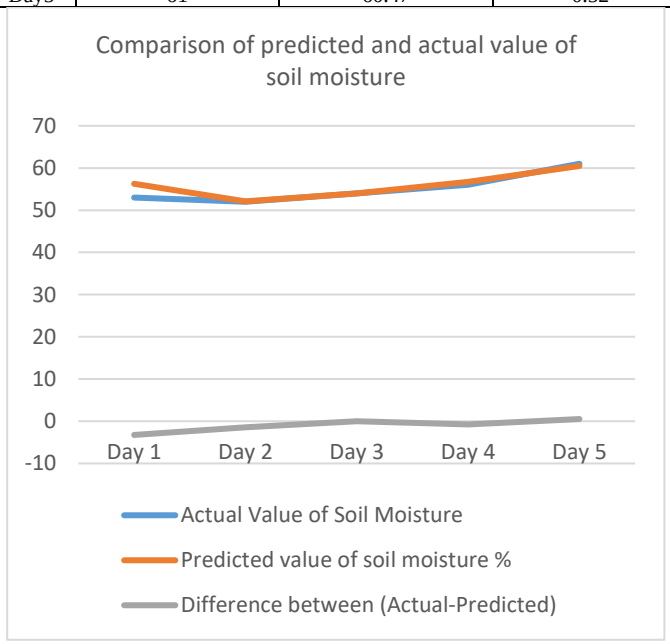

Figure.17. Graph of Table III

VI. Conclusion

The purpose of the paper is to introduce a very low-cost efficient agriculture monitoring and control system for the development of the country's agriculture factor and address existing problems i.e., extra use of water, more human efforts, Less crop yield, and many unwanted conditions

This paper gives a system of IoT based technology. The focus of the study is to maximize crop production and minimize the farmer's and workers' efforts.[6] This proposed system also provides the conservation of water for the crop by using an automatic watering system. More ever Estimating different parameters allow farmers to monitor agriculture more accurately and get an efficient system for obtaining maximum crop yield in less effort.[4] The accurate and precise real-time reading will avoid the death of crops and increase the yield of production significantly. IoT technology enables to monitor and control of agriculture in real-time from remote areas.[2] Blynk app will provide all necessary notifications and reading of the agriculture.[9] This system gives a complete protection system for all agriculture with maximum production and less human effort.

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