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IOT BASED SMART IRRIGATION SYSTEM USING NODE MCU 8266 AND SOIL MOISTURE SENSOR

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Abstract—**This research work is focused on the development of Internet of things (IOT) Based Smart Irrigation system. This project was borne out of the problems or difficulties farmers experience to manually irrigate each corner of a large farmland. Therefore, the system utilizes Nodemcu for smart monitoring and controlling of the traditional irrigation system. The system deploys soil moisture sensor to measure the soil moisture level of the soil and Nodemcu which provides Wireless Access Point (WAP) for Wi-Fi connections. Object oriented methodology was deployed, the system components was seen as different objects that interact with each other to produce the entire result. The soil moisture sensor measures the soil moisture level and based on this sensor value, the Nodemcu controls the 5v water pump to irrigate the farmland. In addition, the wireless technology integrated into the Nodemcu shall be used to send the soil moisture level to the farmer's device, which helps to monitor the farmland. The system also enables the storage, retrieval and visualization of sensor data from the database on the web browser. The database processing is designed using Php and MySQL. The microcontroller aspect of the system is programmed in C++ using Arduino IDE (Integrated Development Environment). Therefore, the IOT based system developed in this study senses the soil moisture level of the soil and if it's below threshold the water pump irrigates and the pump is turned off once the threshold is reached, the sensor readings are sent to the database and can also be visualized in real time by the farmer on his webpage, farmers can keep an eye on the reference values which will help increase production and ease of farming.**

Keywords- **Soil Moisture, Threshold, Water, Sensor, Output Devices, Database, Water Pump, Microcontroller.**

I. INTRODUCTION

The function of agriculture in developing nations is crucial. Most people in Africa depend on farming. The growth of agriculture in developing nations is hampered by numerous problems Insufficient water supplies are one of the world's biggest issues, and water is crucial to agriculture, according to Darshna et al. (2015). Consequently, a suitable water consumption system is needed. Almost all irrigation systems now are physically regulated. One of the biggest benefits of a smart irrigation system, according to Shawn (2019), is its capacity to conserve water. Traditional watering techniques can waste up to 50\% of the water they utilize owing to irrigation, evaporation, and over-watering inefficiencies. Utilizing sensors, smart irrigation systems gather data in real-time or over time to adjust watering schedules and guide watering practices. He goes on to say:
Control types, which refer to how the irrigation is managed, and delivery types, which refer to the various water delivery techniques used, are the two main components of smart irrigation.

Furthermore, there are two primary types of control for smart irrigation systems: soil-based control and weather-based control, each having a different technical approach to sensing and data provision. Zach (2018) claims that substantial flood damage is not always caused by intense weather. Water damage can also happen when older systems are unable to handle the large amounts of water that must be managed. We will need a variety of approaches to address this issue, but it is already apparent that IOT may be a key pillar in the effort to combat water damage. By bringing long-established sensors and control systems online, the internet of things allows us to more intelligently control the flow of water, lessen water damage, and manage the quality of water. Although there are many ways this could function, we have identified three main ways businesses are putting sensors and systems online to prevent water damage.

Hence the project aims at making agriculture smart using automation and IOT technology. The highlighting feature of this project includes smart irrigation with smart control and intelligent decision making based on accurate real time field data.

Most of the developing nations still rely on agriculture as it is heavily vital for their economic soundness as well as social stabilization. Despite this, several factors have presented themselves to hinder progress; one such factor is the scarcity of water. Agricultural productivity is fundamental towards maintaining sound management of water. In addition to this, 50% of water is wasted using manual control of irrigation through evaporations, runoff, as well as inefficiency brought about by overwatering. All these problems will be taken care of by modern smart irrigation systems running through the Internet of Things. These smart systems collect real-time data on soil moisture and other connected devices to optimize the watering schedule. For example, they can start irrigation when the soil moisture falls below a certain level or stop it when a saturation level is reached. This will mean precision watering, so it is spread in a manner that involves not too much wastage, particularly if trickle and subterranean systems combine to optimize the reduction of losses by evaporation. IoT has much more applications in agriculture than irrigation alone. Precision farming is an approach in which sensor data with analytics are used to adapt farming practice according to the need of a particular field. Soil condition, crop health, and environment can be monitored using IoT devices. For example, integrated climatic data with crop monitoring systems may have the potential to improve the yield and resource use efficiency. The systems of IoT that are applied in the management of livestock monitor animals' health, behaviors, and locations in real time to enhance further the welfare and productivity of these animals. Smart devices will notify the farmer about diseases and outbreaks. Drones are also used since the tracker in drones enable real-time mapping and location monitoring. Sonali et al. (2015) proposed a paper in which soil parameters such as pH, humidity, moisture and temperature are measured for getting high yield from soil.

The potential of IoT is in the mitigation of environmental challenges. Karan et al (2015) claimed that an automated irrigation system where the humidity and temperature sensors are used to sense the soil conditions and based on that microcontroller will control the water flow.Advanced drainage systems in cities are reducing the risks of flooding and can manage stormwater runoff, which is the primary cause of water pollution. Agriculture has been improved by solutions driven by IoT to manage the scarce water supplies sustainably and address the growing demand for food globally and climate change impacts. Greater use of IoT demands greater connectivity. Cellular networks are the only means of communication that allows remote IoT devices to ensure seamless data transfer and control. Farmers can monitor their irrigation system, analyse data, and ensure the optimal functioning of their devices from remote areas. This is a technological revolution in the integration of IoT into agriculture, making the process of farming data-driven and enhancing productivity, sustainability, and resilience. Issues such as the management of water and other resources become critical in systems based on IoT, for these are the very factors shaping the future of agriculture, especially in places where the challenges of water scarcity and food insecurity are most pronounced.

II. LITERATURE REVIEW

According to Souparno et al. (2018) the automatic irrigation control uses Arduino uno and timer to manage and control the motor over time. This process not only records values of temperature and humidity it also controls the motor accordingly. Analysing the weather condition motor will automatically maintain water supply making it possible to maintain greenery without human intervention. Vaibhav et al. (2020) designed a system which places DHT11 and soil moisture sensor in a field which sends the sensor information to the Arduino microcontroller. This sensed values from sensors are displayed in Liquid Crystal Display (LCD). If sensed value goes beyond the present value, then the pump will automatically turn off by relay circuit. Global System for Mobile Communication (GSM) module also was used for receiving current information about land on their cellular phone. According to Balamurugan et al. (2017) an irrigation system was designed which mainly consist of Arduino,

Temperature sensor, XBEE, Relay, Valve, Pump and UPS. The temperature from the atmosphere is measured. The temperature sensor used is LM35. The LM35 is precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius temperature. The LM35 temperature sensor operates at -55˚ to +120˚ temperature range. LM35 has three terminals and required Maximum of 5.5 V supply. This type of sensor consists of a material that performs the operation according to temperature to vary the resistance. This change of resistance is sensed by circuit, and it calculates temperature.

Temperature sensors directly connected to microprocessor input and thus capable of direct and reliable communication with microprocessors. The sensor unit can communicate effectively with low-cost direct and reliable communication with microprocessors. The temperature sensor unit can communicate effectively with low-cost processors without the need of A/D converters. Archana and Priya (2016) advocated placing humidity and soil moisture sensors in the plant's root zone. The microcontroller is utilized to manage the water supply to the field based on the measured data. The farmer is not informed by this system of the condition of the field. To simplify the irrigation system, Subalakshmi (2016) proposed a paper. The complexity of irrigation is handled by an automation system employing a microcontroller and GSM. When these parameters exceed the threshold value defined in the program, the GSM sends a message to the farmer based on the detected readings from soil moisture, temperature, and humidity sensors. This technique does not determine the amount of nutrients in the soil. According to a paper that Balaji et al. (2016) proposed, the system uses photovoltaic cells to harness the power of sunlight. There is no reliance on electricity for this system. The soil moisture sensor has been used, and the PIC microcontroller is used to ON/OFF the motor pump based on the measured values. This method does not include weather forecasting. Chavan et al. (2014) presented a smart Zigbee wireless sensor network for tracking environmental conditions. These nodes wirelessly transmit data to a centralized server, which compiles, saves, and enables data analysis and display as required in addition to sending data to the client mobile. In this system, neither weather prediction nor nutritional content are calculated.

A. Architecture of the New System

The new system is made up of the control, detection, output unit and visualization unit.

1. Control Unit: This unit accepts input signals (data) from the Object detection unit and processes the signal to give expected feedback. The NODEMCU is the main control unit of the smart irrigation. It controls the sensors and irrigates the soil depending on the soil moisture

III. PROPOSED ALGORITHM

The proposed system uses the Soil moisture sensor to monitor the farm to know when its moisture content goes below threshold. The system should regularly log current sensor information to the database, display it on the web browser for visualization and turns on the water pump to irrigate the farm if the moisture level goes below threshold. If the system is in its normal state (Soil moisture in normal range), it should still be visualized, and the water pump should remain off.

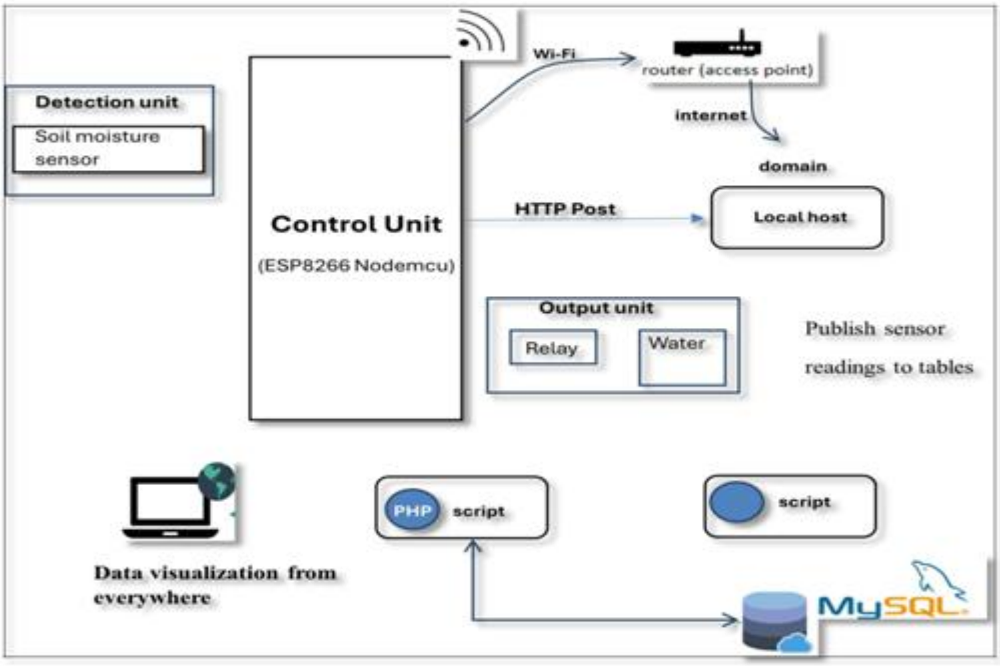

Fig 1. Block Diagram of the proposed new system

threshold detected. The microcontroller board was selected by understanding some of the features it provided. These features will assist us in fulfilling the objectives specified earlier.

Fig 2. Esp8266 Nodemcu (snapshot)

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This microcontroller has been programmed to collect sensor data (Air state), do all required analysis and computations and then triggers the corresponding output units.

Nodemcu has the following Features and Specifications:

Table 1: Specifications of Nodemcu

Specification	Values
Microcontroller:	Tensilica 32-bit RISC CPU Xtensa LX106
Operating Voltage:	3.3V
Input Voltage:	7-12V
Digital I/O Pins (DIO):	16
Analog Input Pins (ADC):	1
UARTs:	1
SPIs:	1
I2Cs:	1
Flash Memory:	4 MB
SRAM:	64 KB
Clock Speed:	80 Hz

2. Detection Unit: This unit is made up of the soil moisture sensor, the soil moisture sensor placed on the surface of the soil senses the soil moisture content of the soil, the sensed data is transmitted to the control unit.

Soil moisture sensor
This sensor has a fork-shaped probe with two exposed conductors, which acts as a variable resistor (just like a potentiometer) whose resistance varies according to the water content in the soil.

Fig. 3 Soil Moisture Sensor probe(snapshot)

Specifications of the soil moisture module are as follows:
a. The sensor also contains an electronic module that connects the probe to a microcontroller.
b. The module produces an output voltage according to the resistance of the probe and is made available at an Analog Output (AO) pin.
c. The same signal is fed to a LM393 High Precision Comparator to digitize it and is made available at an Digital Output (DO) pin.

Soil Moisture sensor Pin Configurations:
a. AO (Analog Output) pin gives us an analog signal between the supply value to 0V and will be connected to one of the analog inputs on your Arduino.
b. DO (Digital Output) pin gives Digital output of internal comparator circuit. You can connect it to any digital pin on an Arduino or directly to a 5V relay or similar device.
c. VCC pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V – 5V. Please note that the analog output will vary depending on what voltage is provided for the sensor.
d. GND is a ground connection.

3. The Output Unit: This unit can also be called the actuators. They are used by the system to either give feedback or control real life situations. The DC water pump has been used as an output unit as discussed below:

The DC Water Pump:

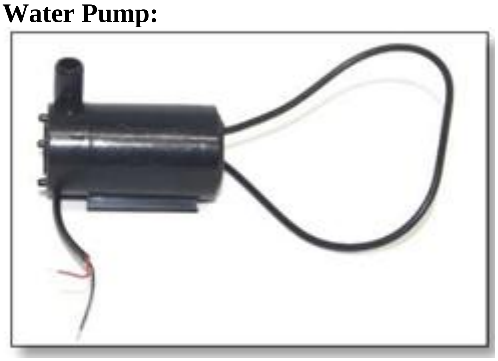

Fig.4 Dc Water Pump (snapshot)

The water pump is used in the project to irrigate the soil in case of moisture shortage. It has two terminals: red (+5v) and black (0v). This is a low cost, small size Submersible Pump Motor which can be operated from a 2.5-6V power supply. It can take up to 120 litres per hour with very low current consumption of 220mA. Just connect tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise.

Visualization Unit:
This unit is designed with HTML and JavaScript, a web page is also developed which displays the sensor readings, timestamp and other information from the database. Data can be visualized from anywhere in the world by accessing local server.

The Power Supply:
The smart cane is powered by a 9v non rechargeable battery.

B. System Implementation
The microcontroller was programmed using embedded C++ in Arduino IDE in order to carry out all processing functions. This IDE enabled us to design a sketch (Write code) for the system. It also provides facilities for verifying (compiling) and uploading the code to the microcontroller for all control and sequencing functions.
But the sensor data from the microcontroller is sent to the local server (where PHP code and MySQL live) for data processing, storage and retrieval. When the data is retrieved from the database, PHP script then posts it to the browser for display and user's view and analysis. Hence, the languages for the design of the user interface are HTML, CSS and JavaScript. For the backend, PHP and MySQL languages have been used. Other frameworks were also used bootstrap and jQuery.
The procedure is as follows:

1. Load Arduino IDE.
2. Create a new sketch and save it with a file name.
3. Design the sketch (write your control code).
4. Click on the verify button to compile the code. If errors were found, debug them and verify again.
5. Click on the upload button to upload (send) the sketch to the microcontroller. If there is port connection problem, debug it and try again.
6. Observe the system work according to your sketch.

IV. EXPERIMENT AND RESULT

The IOT based Smart Irrigation system was tested, and the outcome is as discussed below:
Test Plan
The system shall be tested in terms of power on and followed by the operation test. These tests have been discussed below:

Power on Test
The system shall be powered on by pressing the ON/OFF switch at the right side of the casing. Once the switch was pressed, the 9v battery in the casing supplied the required voltages to all the components of the system. A blue LED attached to the front of the casing blinked to indicate that the system was booting. It took about 2seconds for the system to power on.

Operational Test
The system was tested while in operation. After booting, the Soil Moisture sensor was activated. The user enabled Wi-Fi connection between the android phone and the smart system. After a successful Wi-Fi connection, the admin logged in with his username and password and was able to view the most recent soil moisture readings represented in a tabular form. (See figure 25)

The Soil moisture sensor was able to detect a low moisture content of the soil and caused the water pump to be turned on.

All the above tests have been thoroughly summarized in table 2 below:

Table 2: Summary of the test carried out on the smart system

Event	Expected Action	Actual Action	Remark
The system was powered on	**All components should receive specified input voltage to power on**	**All components were powered by 9v battery used.**	**Good**
User enables inter-device Wi-Fi connections.	**The smart system should connect to the phones hotspot (access point) and the online interface should indicate that connection is made.**	**The connection was successful, and the online interface indicated it.**	**Good**
	The Soil moisture sensor	**The soil moisture sensor**	**Good**

The soil moisture sensor sends its current readings to the database and on the web browser for the user to view them.	**should send its current readings to the database and on the web browser for the user to view them.**	**sent its current readings to the database and on the web browser and the user viewed them.**	
The water pump is turned on if the moisture content of the sample soil goes below threshold (40%).	**The water pump should be turned on if the moisture content of the sample soil goes below threshold (40%).**	**The water pump actually turned on as soon as the moisture content of the sample soil went below threshold (40%).**	**Good**

V. CONCLUSION

The research work “Design and Construct an IOT Based Irrigation System” has been finally completed, tested and confirmed to be working in line with Aim and Objectives stated earlier. The soil moisture senses the moisture level of the soil and the Nodemcu triggers the water pump to irrigate based on the measured soil moisture level, the sensor readings are stored in the database and also viewed in the webpage.

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