IoT-Based smart irrigation system using artificial intelligence

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Abstract: **Regarding Agriculture Monitoring based on land or crops in the modern agricultural system, networking technology has been crucial. Since farmers can control their activities even more readily than before, it is possible to make choices even when farmers are not present. This also applies to water management in irrigation systems. The Internet of Things (IoT) keeps track of real-time data analysis from every agricultural crop that is gathered by sensors and devices. The irrigation techniques and patterns used in a nation like India, where agriculture is predominately centered on the unorganized sector, are ineffective and frequently result in needless water waste. A system that can offer an effective and deployable solution is therefore required. Using data on soil moisture, the automatic irrigation system we present in this study can water fields on its own. It is based on Artificial Intelligence (AI) and the Internet of Things (IOT). An intelligent system that selectively irrigates crop fields only when necessary, depending on the weather and current soil moisture levels is created by the system's prediction algorithms, which analyze historical meteorological data to identify and forecast rainfall patterns and climatic changes. With an accuracy rate of 80% during testing in a controlled setting, the technology effectively addresses the issue.**

Index Terms - Artificial **Intelligence, Irrigation, Internet of Things, Prediction Algorithms, Machine Learning, and Water Conservation**

I. Introduction

A smart irrigation system based on water is added to the soil or land during irrigation to support plant development. Rainfall could not always be enough to supply the plants with the water they need to develop, depending on various factors such as area, season, and climate. Most irrigation systems perform database systems resulting in predicting soil moisture. Delivering precise soil-based water estimates and making soil parameters of plans and productivity of crops. Farmers can use scientific techniques such as various irrigation systems and a balanced quantity of herbicides and fertilizers to increase crop output. Crop production is determined by the availability of water, land, rainfall, meteorological conditions, and other factors. More extensive databases for crop and meteorological factors are now accessible. However, the agricultural industry lags significantly behind other sectors utilizing farm data in decision-making.

Figure 1 Smart irrigation system

The requirements of the parameters of sensors, environment, and the function of indigenous institutions in irrigation management contain quantities of data. Furthermore, in regular and sufficient maintenance, irrigation systems decline quickly and cease to offer the desired quality within their design life. Many irrigation systems have also had negative impacts on the environment. The Internet of Things (IoT) based Neural Network algorithm techniques used to collect the generated data must first be identified for them to be examined and evaluated. To carry out these tasks, a significant quantity of data is necessary. This data will lose all relevance, structure, and process. Some challenges in implementing precision agriculture are linked to data management, network management, and plant health condition.

Each node receives a substantial quantity of sensor observations, adding to the complexity of the network. As the Internet is a virtual network of devices, it plays a big part in each application examined, which is the downside of typical internet usage. The expertise necessary for a farmer to use agricultural technology efficiently is above that of a conventional technique. In most conditions, the end users will only have a basic understanding of precision agriculture. However, their expertise is insufficient to convert a technology for uniform crop production into a precise agriculture technology.

1.1 Objectives

The project focuses on these objectives, which are:

- To measure field temperature periodically by deploying a sensor.
- To make use of solar power which could be generated even in remote areas.
- To decide the need to provide irrigation to the crops based on soil moisture data.

1.2 Scope of Smart Irrigation System

By evaluating the condition of the soil and climate, water supply for irrigation may be readily regulated by employing sensors like moisture, rain, etc. Intelligent soil moisture sensors assess soil moisture and using that information, fields are automatically watered with fewer human interventions.

II. LITERATURE REVIEW

Ahmed et al. 2013, in this work, automated security and irrigation control systems with wireless messaging capability. Our work's primary goals are to optimize efficient water usage, reduce losses, and offer security. Operating two pumps keeps the necessary water level in the field and throws extra water during hard, heavy rains.

Ajayi O et al. 2022, Measurements are utilized to express the amount of these characteristics and determine the overall water quality, such as the Water Quality Index (WQI) and Irrigation WQI (IWQI). To do this, this paper suggests a network architecture for collecting real-time data on water characteristics and using Machine Learning (ML) methods to automatically decide if water samples are suitable for drinking and irrigation.

Akanksha. E et al. 2021, the methodology consists of four stages: preprocessing, feature extraction, classification, and segmentation. Initially, the images are converted into RGB format, and the images present in the noises are removed. Then, the R band is given to the feature extraction stage. Then, the selected attributes are fed to the classifier to classify an image as normal or abnormal. For classification, an Optimized Probabilistic Neural Network (OPNN) is utilized. The PNN classifier is improved by using the artificial jelly optimization (AJO) algorithm.

Alghazzawi. D et al. 2021, the greenhouse makes planting more straightforward, which has several advantages for agriculture. Gas sensors and soil pH sensors are frequently employed in agricultural modeling. These sensors may be used for a variety of IoT-integrated farm applications. The suggested model's hardware architecture and operation are covered in the technique. Additionally, numerous agricultural evapotranspiration models are described. The Penman-Monteith equation examines essential issues, such as congestion control.

Alharbi. H et al. 2021, The real-time monitoring, tracking, analysis, and processing of numerous operations and services using the Internet of Things (IoT), cloud, ambient, edge computing, artificial intelligence, and agricultural robotic systems. Additionally, by employing automated systems and removing human interference, these technologies can improve farm productivity and match future expectations by making agricultural operations more intelligent and resourceful.

Amin A. B et al. 2021Analysis of plant development under regulated environmental conditions is possible in a greenhouse setting. It isn't easy to simulate various climate intensities simply by altering the soil moisture, though. To investigate how this crop's genetic responses to drought stress are affected, this section presents a sensory and control system to imitate drought conditions for wheat. The drip irrigation system keeps potted wheat plants' soil moisture levels within a predetermined range.

Anand. T et al. 2021 Imbalance the agriculture, including standing water and weed patches, interfere with farming operations, resulting in incorrect utilization of the farmland and upsetting agricultural planning. Modern agricultural techniques might be more effective by monitoring fields and crops using Internet of Things (IoT)-enabled intelligent technologies. Remote sensing using Unmanned Aerial Vehicles (UAVs) is an effective method for gathering detailed photographs of farms. The development of AI-assisted farming models using visual data analytics for automatic pattern detection from the acquired data has significant potential for enhancing farming outputs by identifying crop trends.

AngelinBlessy et al. 2021 computer learning. Due to the efficient use of resources and generation of yields, it is crucial and necessary to civilization. Practical methods are required to monitor moisture levels, improve water use, and boost yields. This article discusses cutting-edge methods for combining IoT and artificial intelligence in agricultural irrigation systems. This browser presents the different parts, modern irrigation system, many comparative metrics, and its needs.

Assaf. R et al 2020, over time, the amount of rainfall has decreased, and springs are becoming drier. As a result, the irrigation system is one of the most frequently employed in agriculture. The kind of soil, its fertility, its moisture content, its humidity, and its temperature are just a few of the many variables that should be considered when determining how much water should be supplied to the plant when employing an irrigation system. To automate the watering schedule for the plants, our suggested irrigation system takes these considerations into account.

Badran et al. 2021 The irrigation industry may benefit from the Internet of Things (IoT) innovative solutions, which can enhance irrigation management and lower operating infrastructure maintenance costs. The incapacity of stakeholders to transform accessible data into in-depth, reliable information that can be used in decision-making is one of the most significant issues in intelligent irrigation systems.

Bhat et al. 2021 Precision agriculture uses big data (machine learning, deep learning, etc.) because of its ability to analyze vast amounts of data and crucial abstract information and help agricultural practitioners understand farming operations and make accurate judgments. This comment's main objective is to educate readers about the most recent Big Data applications in smart agriculture and the accompanying social and financial concerns.

III. Materials and Methods

The power supply provides electricity to an electrical load, such as a server or laptop computer, among other electronic devices. Converting electric current from a source to the proper voltage, current, and frequency to power the load is the primary purpose of a power supply. The relay works on the principle of electromagnetic field induction, the relay act as one of the controllers. By opening and stopping the flow in response to the signal from the sensor and supplied through the Arduino controller, a water pump regulates the flow of water. If the root depth will reach high, the pump will be in OFF State otherwise the pump is kept in ON. Always the relay controlling on the pump. DHT 11 sensor to measure both humidity and temperature. This sensor operating voltage is 3V to 5V, the sampling rate of the DHT11 is 1Hz, in single plant, and system will make a single irrigation level.

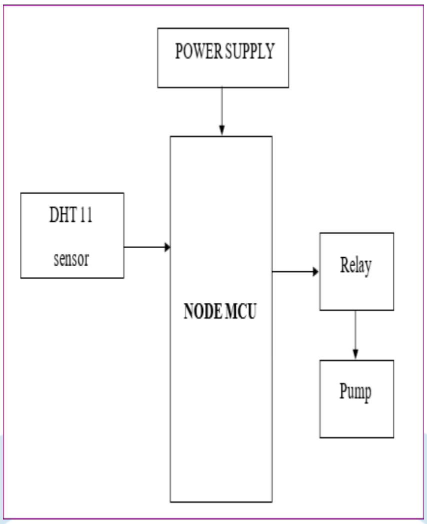


Figure 2 Multiple Plant System

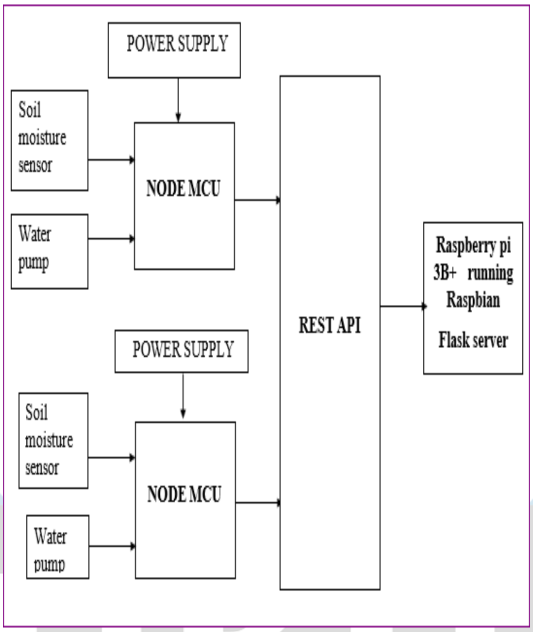


Figure 3 Single Plant System

IV. HARDWARE REQUIREMENTS

a. Introduction of IoT (Internet of Things)

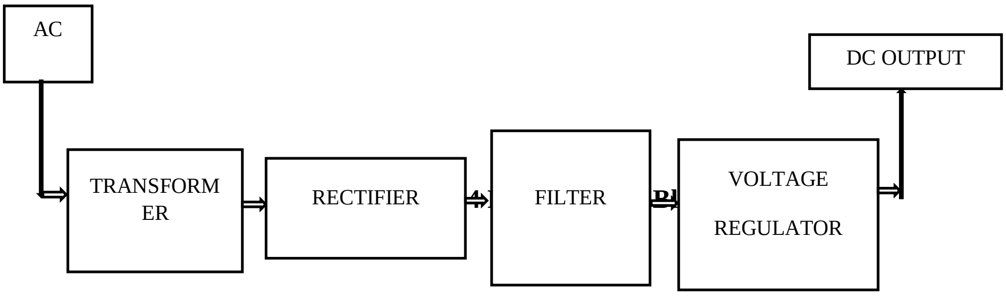
The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with Unique Identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices for instance, to set them up, give them instructions or access the data.

The internet of things helps people live and work smarter, as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations. IoT enables companies to automate processes and reduce lab (or) costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods, as well as offering transparency into customer transactions.

b. Power Supply

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters.



c. Transformer

A transformer is defined as a passive electrical device that transfers electrical energy from one circuit to another through the process of electromagnetic induction. It is most commonly used to increase (‘step up’) or decrease (‘step down’) voltage levels between circuits. The working principle of a transformer is very simple. Mutual induction between two or more windings (also known as coils) allows for electrical energy to be transferred between circuits. A step-down transformer is a type of transformer that converts the high voltage (HV) and low current from the primary side of the transformer to the Low Voltage (LV) and high current value on the secondary side of the transformer. The reverse of this is known as a step-up transformer.

A rectifier is an electrical device that converts Alternating Current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The reverse operation is performed by the inverter. A bridge rectifier uses four diodes to convert both half cycle of the input AC into DC output. The purpose of power supply filters is to smooth out the ripple contained in the pulses of DC obtained from the rectifier circuit while increasing the average output voltage or current. A voltage regulator is a system designed to automatically maintain a constant voltage. A voltage regulator may use a simple feed-forward design or may include negative feedback. It may use an electromechanical mechanism or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

The quantity of water vapor in the air is measured as humidity. The amount of humidity in the air has an impact on a number of chemical, biological, and physical processes. Humidity can have an impact on staff health and safety, company costs associated with the products, and employee safety. So, measuring humidity is crucial in the semiconductor and control system sectors. The quantity of moisture in a gas—which might be a combination of water vapor, nitrogen, argon, or pure gas, for example—is determined by its relative humidity. Based on their measuring units, humidity sensors may be divided into two categories. A relative humidity sensor and an absolute humidity sensor are what they are. A digital temperature and humidity sensor is the DHT11.

d. Relay Module

The relay is the mechanism that activates or deactivates the contacts to activate the other electric control. When an allocated area experiences an unbearable or unpleasant situation, the circuit breaker is instructed to disconnect that region. There by guards against harm to the system. It functions on the idea of electromagnetic attraction. The electromagnetic field that creates the temporary magnetic field is energized when the relay's circuit detects the fault current.

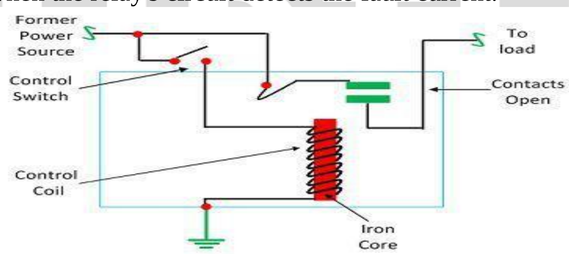


Figure 5 Diagram of Relay

The relay armature is moved by this magnetic field to open or close connections. The high-power relay has two contacts for opening the switch, compared to the small-power relay's single contact. The figure below depicts the relay's interior part. It has an iron core around which a control coil has been coiled. Through the connections of the load and the control switch, the coil receives power. The magnetic field that surrounds the coil is created as current travels through it. The lower arm of the magnet is drawn to the higher arm by the magnetic field. Therefore, complete the circuit, causing current to flow through the load.

e. Pole and Throw

The configurations of a relay are its pole and throws, where the pole is the switch and the throw is the number of connections. The simplest sort of relay, with just one switch and one potential connection, is a single pole, single throw. The single pole double throw relay is similar in that it has one switch and two potential connections.

f. Water Pump

The basic purpose of a pump, which is defined as a common mechanical device, is to push a gas that would normally flow through a pipeline. These are also used to compress gases so that wheels don't have to be inflated with air. Pumps pressurize the liquids to pull them in and release them throughout the exit by using mechanical energy. The primary energy sources for pumps include wind power, human power, electricity, and engines.

Figure 6 Model of Pump

A pump's basic operation is to increase fluid pressure in order to provide the necessary driving force for flow. The pressure filter supply pump is typically a centrifugal pump, and the way it works is that slurry enters the pump by the revolving impeller's eye, which causes the pump to rotate in a circular motion.

Volumetric flow rate, horsepower, opening pressure within meters of the head, and inlet suction within a meter of the head are often listed as their ratings. Here, the head may be made simpler since more feet can go up a water column at atmospheric pressure than would otherwise be possible. Engineers typically use a number known as the exact speed from an early design point of view to identify the best pump for a precise flow rate combination as well as the head.

h. Node MCU ESP 8266 Wi-Fi Module (IOT HARDWARE):

The ESP8266 Node MCU CP2102 board has ESP8266 which is a highly integrated chip designed for the needs of a new connected world. It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.

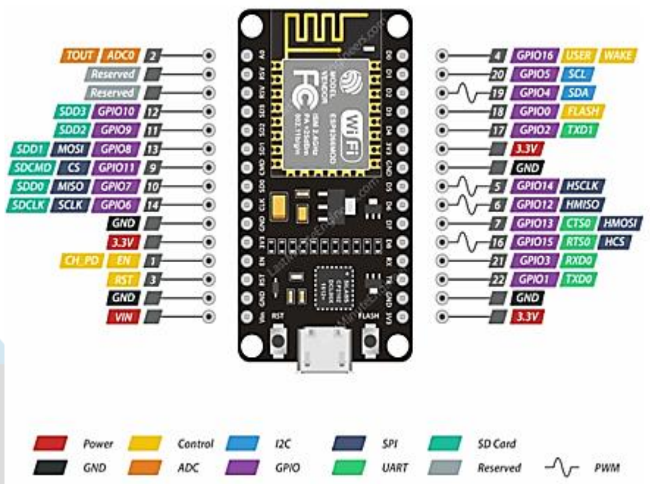


Figure 7 ESP8266 NODEMCU Pin configuration

ESP8266 has powerful onboard processing and storage capabilities that allow it to be integrated with the sensors and other application-specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, and the entire solution, including the front-end module, is designed to occupy minimal PCB area.

The ESP8266 Node MCU development board – a true plug-and-play solution for inexpensive projects using Wi-Fi. The module arrives pre-flashed with Node MCU firmware ESP-12 Lua Node MCU WIFI Board Internet of Things board contains a full ESP8266 Wi-Fi module with all the GPIO broken out, a full USB-serial interface, and a power supply all on the one breadboard-friendly package.

ESP8266 Node MCU has 17 GPIO pins which can be assigned to various functions such as I2C, I2S, UART, PWM, IR Remote Control, LED Light, and Button programmatically. Each digitally enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU interrupts. The Node MCU is embedded with a 10-bit precision SAR ADC. The two functions can be implemented using ADC viz. Testing power supply voltage of VDD3P3 pin and testing input voltage of TOUT pin. However, they cannot be implemented at the same time.

ESP8266 Node MCU has 2 UART interfaces, i.e., UART0 and UART1, which provide asynchronous communication (RS232 and RS485), and can communicate at up to 4.5 Mbps. UART0 (TXD0, RXD0, RST0 & CTS0 pins) can be used for communication. It supports fluid control. However, UART1 (TXD1 pin) features only data transmit signal so, it is usually used for printing log. ESP8266 features two SPIs (SPI and HSPI) in slave and master modes. These SPIs also support the following general-purpose SPI features:

IV. Conclusion

The Internet of Things will help to enhance smart irrigation. With the use of sensors and the Internet of Things, we can forecast the temperature, humidity, and soil moisture level. IoT technology and information recording in Python with fuzzy logic may be used to monitor and operate irrigation systems. When predators are used, crop damage is decreased. IoT works in several facets of farming to increase productivity, water management, crop monitoring, and soil management. Mobile IoT applications retain sensor data and provide alerts to worried farmers. It also reduces the need for human labor, makes agricultural methods simpler, and promotes smart farming. In addition to these benefits, smart farming may expand the market for farmers with a single touch and little work. We are able to anticipate the temperature, humidity, and soil moisture content thanks to sensors and the Internet of Things. To monitor and manage irrigation systems, IoT technologies and information recording in Python with fuzzy logic may be employed. Crop damage is reduced when predators are utilized. IoT improves productivity, water management, crop monitoring, and soil management in several aspects of farming. Applications for mobile IoT save sensor data and inform farmers who are in danger. Additionally, it facilitates smart farming, simplifies agricultural practices, and eliminates the demand for human labor. In addition to these advantages, smart farming might easily and quickly increase the market for farmers.

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