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Automated Irrigation System Using IoT Cloud Computing

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Abstract

In India, 85% freshwater is used in agriculture. This percentage continues to lead in water consumption. The population evolution and increased food demand are one of the primary factors of water maximum utilization. Therefore, primarily, agriculture is contingent on the monsoon, which is not an adequate source of water. So, irrigation is lively in the agricultural zone. Nowadays, with the constant evolution of Artificial Intelligence, IOT and Robotics, the development of monitoring and observing the garden from manual and static, can be transformed into a smart, dynamic one that is central to higher convertibility, water use productivity, and fewer human supervision exertion. This paper focuses on Internet of Things (IOT) computing, smart garden surveying, and irrigation structure, using Mega 2560. The proposed system uses a microcontroller, sensors, and a cloud server that provides real-time web concluded through a Wi-Fi network. The observed data, directed endlessly to the ThingSpeak IOT cloud. The data gathered in the cloud from the system is examined and analyzed. When the target threshold of soil moisture is touched, an action is sent consequently, cloud to the smart irrigation system to irrigate the garden. The microcontroller (Arduino Mega 2560) is implemented to design the control unit. IOT is primarily used to keep the garden owner updated about the position of the sprinklers. The data are frequently updated by the sensors on the IOT cloud. In addition to this, readings are transmitted by the sensors to a cloud channel to produce graphs for analysis.

Keywords

IOT, Smart garden, Arduino Mega, ThingSpeak, Cloud Computing

Introduction

Trickle Irrigation it's an artificial practice used to water the roots of the plants. It is known as micro-irrigation. An automated irrigation construction is planned to simplify overcoming efficient irrigation, water, and labor shortage circumstances. For high consistency, robustness, and restricted properties, resistive sensors are selected. Here, it can be considered for smart homes, smart buildings, smart cities, as well as smart healthcare. It also focuses on applications in smart energy, smart electrical grid, and also considers the smart waste management system. It focuses on a smart garden watering system that is constructed on an IoT cloud and Arduino Mega. The total amount of water required for the plant can be adjusted when exact data about the moisture of the soil is recognized. It evades the plant that is being overwatered or underwatered. The soil moisture percentage is measured by means of a soil moisture sensor, moisture present in the soil based on the change in resistance between two conducting plates of the sensor. Sensors send the real-time values to Arduino. These values are then sent to the cloud server via serial communication. Since Arduino Mega is a microcontroller, it cannot connect itself to the internet. For that persistence, the ESP8266-01 Wi-Fi module, a self-contained SOC, is integrated with a TCP/IP protocol stack, which can access a Wi-Fi network. This Wi-Fi module allows the Arduino Mega board to connect with a router and access the internet. The Arduino is programmed in such a way that it can communicate with the cloud platform. The ThingSpeak over TCP/IP protocol. The Arduino Mega 2560 can implement TCP connection by passing AT commands serially to the ESP8266-01 Wi-Fi module. ThingSpeak IoT cloud collects, stores, and analyzes the data sent by Arduino.

The Arduino collects the notification from the cloud (ThingSpeak). The steady value of the moisture level, or the light intensity range the threshold value. A water pump, a light associated with the microcontroller over a relay shield, is motorized on or off condition.

The abilities that are found which is increased by relating to the scheme of IoT cloud:

1. Performance is monitored by the user, as the watering system is online. So, from anywhere, anytime, the value of the moisture level can be stored on ThingSpeak periodically.

2. This is very flexible, as the threshold value of the moisture level is stored.

3. The individual can change these values remotely at any moment.

4. The threshold values can be read by Arduino. From the cloud, it can be automatically adjusted and controlled. The algorithm to cope with the new setting.

SYSTEM ARCHITECTURE

The system architecture is shown in Figure 1. It can be divided into two subsystems, the control subsystem and the IoT subsystem.

A. The Control Sub-System

The subsystem consists of:

1- Arduino Mega 2560microcontroller.

2- ESP8266-01, connects the Arduino board with the internet.

3- Soil Moisture sensor, measures the moisture level of soil

4- Water pump relay, connects the water pump to the Arduino Mega board

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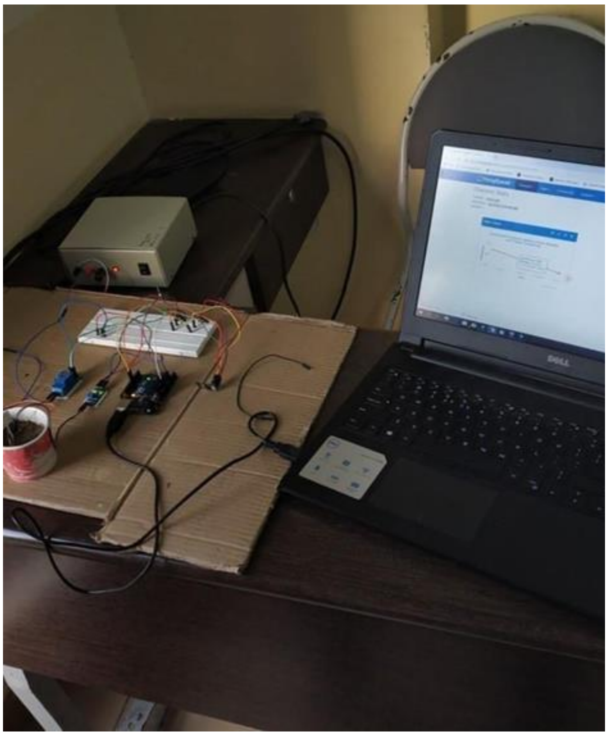
B. IoTSubsystem

To improve the system proficiency, the Arduino Mega 2560 is linked to the IoT cloud. The cloud is the MathWorks analytics, IoT platform that permits the user to gather, store the data, analyze, and perform on data from sensors or hardware devices. Live data is examined in the cloud and Thingspeak delivers instant visualizations of information forwarded by specific devices. The MATLAB analysis is then implemented in



ThingSpeak. It permits users to conduct online analysis of the sensor information generated. Users then create channels in the cloud. The channel contains fact fields. The User writes or reads data to or from the channel. It also processes and views the data with MATLAB code and then rejoins the data with the React app and other necessary alerts. In the proposed system, three channels are created in ThingSpeak: the Analog Reading channel, the Soil Moisture Percentage channel, and the ESP8266 control pump channel. In each channel, one field is created. In the Analog Reading channel, MATLAB analysis is applied to convert the analog reading of the soil moisture sensor to moisture percentage and then store it in the Soil Moisture Percentage channel. Then, in the second channel, MATLAB analysis is applied, so if the moisture percentage is less than the threshold value, then the numeric value 1 will be sent to the ESP8266 control pump channel.

DESIGN AND IMPLEMENTATION OF ARDUINO CIRCUIT

The Arduino Mega circuit is implemented as shown in the figure.2 It consists of a Soil Moisture sensor, one relay for the pump, an ESP8266-01 Wi-Fi Module, and a 12V DC external supply. So, further in advance, this project can be used in the larger field as in four (4) area parts. In each part, a sub-network is constructed of nine (9) ESP8266s, which will work on solar power. In the center of the field, a box can be placed that contains another ESP8266 module, 1 Arduino Mega, a GPRS 3G Arduino compatible module, and a Solar Panel. In each sub-network, the ESPs are in a traditional formation to use 3 as repeaters (the middleman) and the other 6 as sensor readings (the workers). Each middleman ESP8266 will be programmed to listen and receive the readings from the workers, and then send it further to the next middleman up until the ESP8266 of the central box. The central box will be configured to be the Main Cluster data manager, in charge of receiving and

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processing data from the closest middleman.

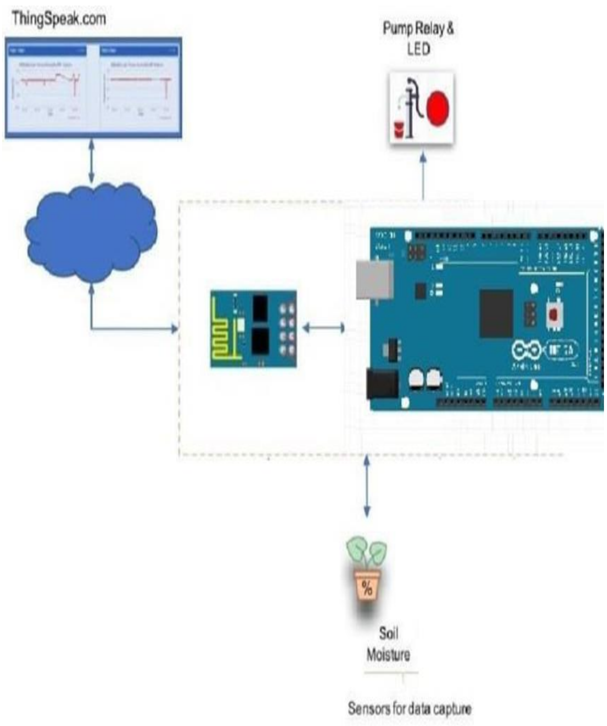

Figure. 1. Smart Watering System Architecture

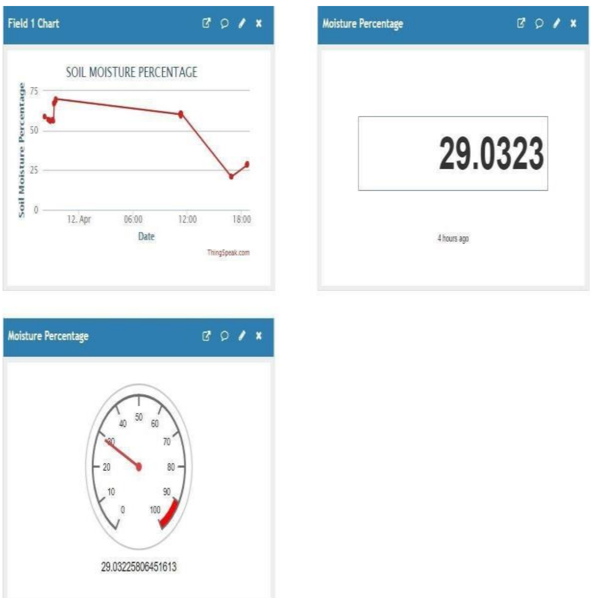

Figure. 2. Implemented Arduino

Figure. 3. Analog Reading on ThingSpeak IOT Cloud

The above graph describes a system that uses an Arduino (Figure. 2) to read soil moisture data from a sensor. This analog data is then sent to and visualized on a cloud platform called TwinSpeak JOT Cloud (Fig. 3). The document shows specific results, including a soil moisture percentage of 60.0% and a "Relative Percentage" of 20.03%, demonstrating the system's functionality for remote environmental monitoring via the cloud.

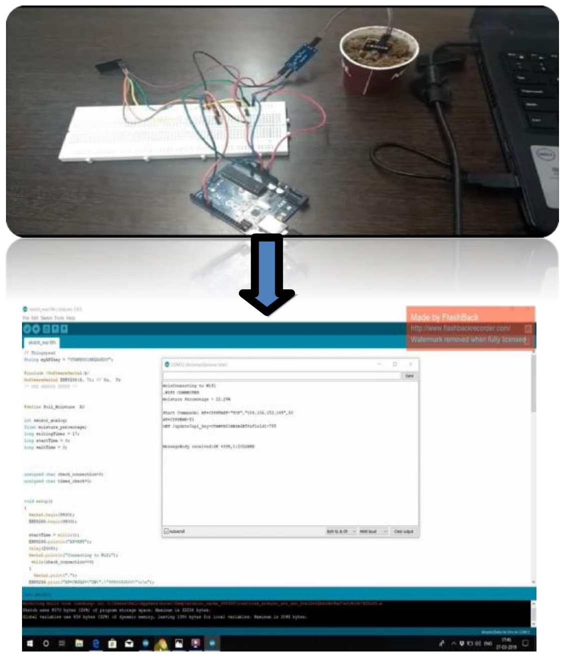

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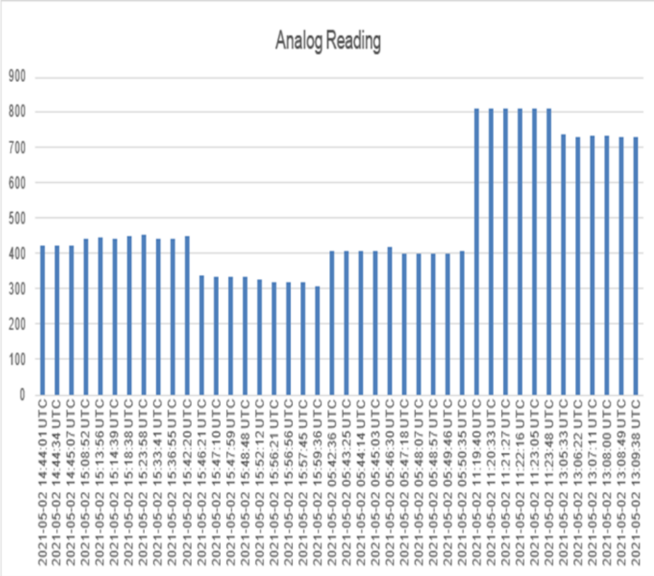
Figure. 4. depicts the Soil Moisture Percentage Channel

Figure 4 represents the implementation and monitoring of a soil moisture sensing system integrated with an Arduino microcontroller for precision agriculture applications. The upper section of the figure shows the hardware setup comprising an Arduino Uno, a capacitive soil moisture sensor, a breadboard, and necessary jumper connections. The sensor is embedded in the soil sample contained in a small cup, where it measures the dielectric permittivity of the soil to determine its volumetric water content. The analog output from the sensor is fed to one of the Arduino's analog input pins, where it is digitized using the onboard 10-bit ADC for further computation. The Arduino is interfaced with a laptop through a USB connection, serving both as a power source and a serial communication interface.

The lower part of the figure displays the Arduino IDE environment, illustrating the code responsible for acquiring sensor data, converting raw analog readings into moisture percentage, and establishing Wi-Fi connectivity to transmit the data to a cloud server for real-time monitoring. The Serial Monitor output confirms a successful Wi-Fi connection and displays calibrated soil moisture percentages. This configuration demonstrates a low-cost, IoT-enabled prototype for automated irrigation control and soil condition analysis.

CLOUD ANALYSIS OF THE DATA



Formula Used= 100 – (Analog output * 100)
To convert analog reading to moisture percentage.

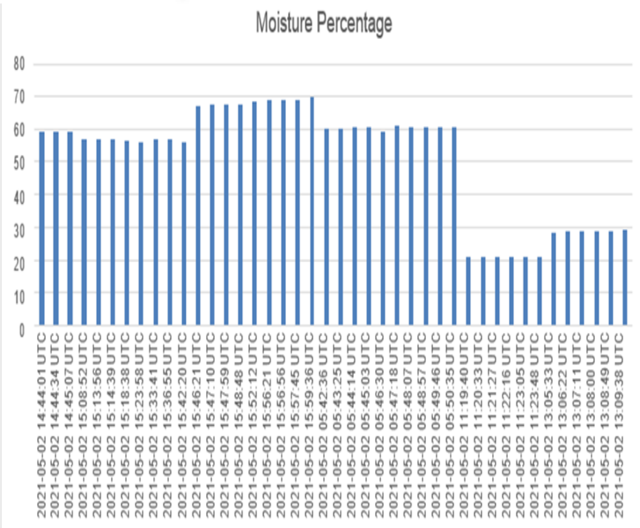


Figure 5

Using this data, a value of 0 or 1 is generated in the cloud using MATLAB analysis and React App. Then this value is fetched from the cloud via Arduino Mega 2560, and then it is processed in the microcontroller to turn the pump on or off automatically. Based on the provided graph, as shown in Figure 5, illustrates an inverse linear relationship between the raw Analog Reading from a sensor and the calculated Moisture Percentage, defined by the formula Moisture Percentage = 100 – (Analog Reading * 100). This means that as the Analog Reading increases, signifying drier conditions, the Moisture Percentage decreases proportionally, with a reading of 0 resulting in 100% moisture and a reading of 1 resulting in 0% moisture.

WORKING PRINCIPLE

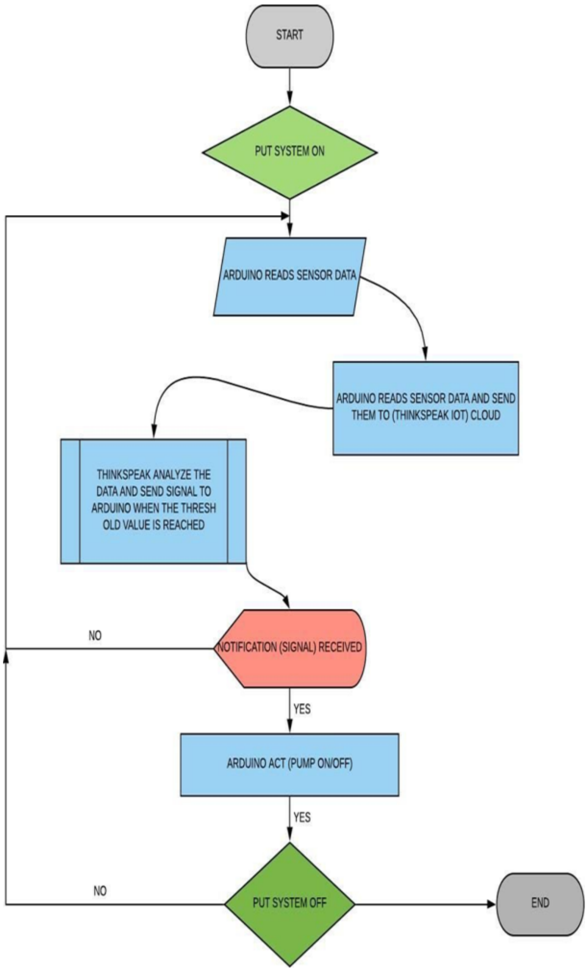


Figure 6: Flowchart of IoT-Based Automated Control System Using Arduino and Thingspeak Cloud

The flowchart titled "Working Principle of IoT-Based Automated Control System Using Arduino and ThingSpeak Cloud" demonstrates the operational workflow of an intelligent automation system that integrates embedded hardware and cloud-based analytics for real-time monitoring and control. This architecture is typically used in IoT applications such as smart irrigation, environmental monitoring, and industrial automation. The process begins when the system is powered on, initializing all connected hardware components, including sensors, microcontrollers, and communication modules. The Arduino microcontroller acts as the central processing unit of the system, responsible for collecting real-time data from various sensors. These sensors can measure parameters such as soil moisture, temperature, humidity, pressure, or any environmental variable, depending on the specific application.

Once the data acquisition phase is complete, the Arduino transmits the collected sensor readings to the ThingSpeak IoT cloud platform using an internet communication module (commonly an ESP8266 or ESP32 Wi-Fi module). ThingSpeak serves as the cloud-based analytical engine, where the raw data is stored, visualized, and processed using MATLAB analytics or custom algorithms. Within the cloud, the system continuously compares the incoming sensor data against predefined threshold values or setpoints that determine normal and abnormal conditions. When the sensor data exceeds or falls below these threshold limits, ThingSpeak triggers an event notification or control signal, which is sent back to the Arduino through the cloud interface. This bidirectional communication enables remote control and automation without human intervention. Upon receiving the notification, the Arduino interprets

Conclusion

This research presents the design and implementation of a technologically advanced and economically viable Trickle (Drip) irrigation system, emphasizing remote operability and future scalability. The system's core innovation lies in its deployment of a cloud-centric architecture, which facilitates real- time data acquisition, remote monitoring, and precise control of irrigation schedules from geographically dispersed locations via the Internet. This infrastructure ensures efficient water resource management through data-driven automation. Future development roadmaps focus on significant technical enhancements to augment system capability and autonomy. A primary objective is the sensor fusion of a more diverse suite of agro-meteorological sensors, including hyperspectral and thermal imaging sensors, to enable precision agriculture based on multivariate analytics. Concurrently, the system's power and communication backbone will be fortified by synergistically integrating the ESP8266 Wi -Fi module with a photovoltaic-supercapacitor power supply system. This integration is engineered to eliminate grid dependency, thereby enabling robust, long-term deployment across expansive and remote agricultural fields. These planned advancements are poised to substantially elevate the system's intelligence, sustainability, and large-scale applicability.

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