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Smart Irrigation System for Optimal Water Conservation

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Abstract:
Agriculture marked a transformative step towards settled human societies, as the ability to cultivate domesticated crops created food surpluses that fueled urban growth. Yet, traditional irrigation methods like overhead sprinklers and flood irrigation are often inefficient, wasting water and sometimes causing issues like soil fungal growth due to excess moisture. Manual irrigation further demands significant time and effort from farmers to monitor soil moisture and apply water as needed. This IoT-based smart irrigation system provides a solution by automating soil moisture measurement, tracking weather conditions, and delivering water with precision. It also allows users to set threshold values for optimal moisture, stopping irrigation once these levels are met. The project aims to empower farmers to manage and monitor irrigation using the Blynk app on their smartphones.

Keywords: IoT, Irrigation, Automation, Monitoring, Blynk App.

I. INTRODUCTION

In recent years, variable weather patterns and shifting environmental factors—such as temperature fluctuations and inconsistent soil moisture—have posed significant challenges for maintaining high-quality farming practices. These external conditions are crucial to crop health, growth rates, and yields, making effective management essential in modern agriculture. Humidity, in particular, plays a vital role, as it influences water retention within plant cells, impacting growth and cellular function. To address these challenges, precise and real-time monitoring of environmental conditions is necessary for timely intervention to promote healthy plant development.

The emergence of the Internet of Things (IoT) has introduced groundbreaking advancements in agriculture, particularly through smart farming. IoT refers to a modern system where everyday objects are equipped with sensors, processors, and connectivity, enabling them to collect, process, and transmit environmental data. This integration allows for a dynamic farming system that autonomously monitors and manages various agricultural processes. By linking IoT-enabled devices through a unified network, farming operations can be automated and adjusted in real time, reducing human labor while enhancing efficiency and crop output.

Within this framework, smart farming utilizes IoT to create a network of sensors and devices that continuously track vital factors affecting crop health, such as temperature, soil moisture, and humidity. These devices not only collect and analyze data but also communicate with each other and with farmers through connected applications, providing actionable insights and enabling automated responses tailored to the needs of specific crops. This interconnected system has transformed traditional farming, offering a proactive method to regulate environmental conditions and optimize resource use for improved crop health and productivity.

II. LITERATURE SURVEY

Minwoo Ryu, formerly a Senior Research Scientist at the Korea Electronics Technology Institute (KETI) in South Korea, currently works with Korea Telecom's Research and Development Center in the same role. His research expertise includes IoT, semantics, cognitive computing, intelligent services, and vehicular ad hoc networks. Ryu developed an IoT-based smart farming system to connect farms, as outlined in his paper published on August 13, 2020. In a related study, M. Usha Rani and S. Kamalesh introduced a "Smart Farming System using IoT for Efficient Crop Growth," leveraging IoT to monitor soil moisture and humidity with a NodeMCU microcontroller. The system sends SMS notifications to farmers via Wi-Fi to keep them updated on crop conditions.

In 2019, Satya et al. proposed a "Water Irrigation System" that adjusts water usage based on soil moisture and water levels, with SMS updates on irrigation timing sent to farmers. Another study, titled "Sensor-based Automated Irrigation System with IoT," published in the International Journal of Computer Science and Information Technologies, describes an irrigation setup using wireless sensor networks (WSN) and water pumps. This system incorporates water level sensors in main canals and flow sensors on pumps, all connected to a wireless gateway that regularly updates a web server. The database continuously monitors irrigation, comparing it to predefined values, and sends SMS alerts to farmers and engineers regarding crop water requirements.

III.PROPOSED SYSTEM

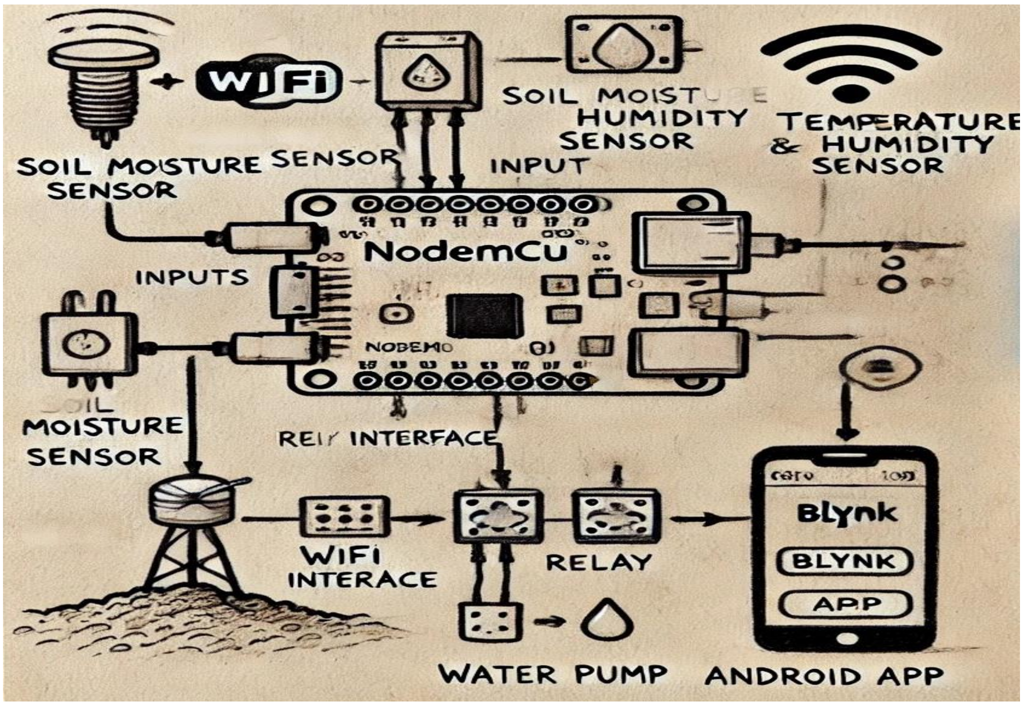

Fig 1: Proposed System design

Figure 1: Proposed System Design for IoT-Based Automated Irrigation and Monitoring System. The system comprises a NodeMCU, soil moisture sensor, water pump, relay, humidity and temperature sensors, and a smartphone interface using the Blynk app for communication. Designed to address the changing water needs of crops or plants at different growth stages, it provides precise irrigation. The smartphone connects to the NodeMCU over Wi-Fi, allowing users to control the motor with ON and OFF commands.

COMPONENTS DESCRIPTION

A. ***Hardware Requirements***

1. NodeMCU

Fig 2: NodeMCU ESP8266

The NodeMCU is an open-source development board with Lua-based firmware, specifically designed for Internet of Things (IoT) applications. Built around the ESP8266 Wi-Fi SoC by Espressif Systems, it incorporates the ESP-12E module, which includes an ESP8266 chip with a Tensilica Xtensa 32-bit LX106 RISC microcontroller. This microcontroller operates at a configurable clock speed of 80MHz to 160MHz and is compatible with RTOS. The NodeMCU provides 128 KB of RAM and 4MB of flash memory for data and applications, delivering high processing power, built-in Wi-Fi and Bluetooth functionality, and a Deep Sleep Mode for improved energy efficiency.

2. Soil Moisture Sensor

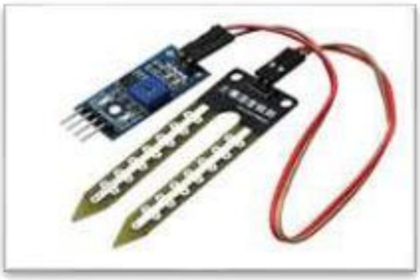

Fig 3: Soil Moisture sensor

Sensors are electronic devices that transform physical measurements into electrical signals. Figure 3 shows the soil moisture sensor used in this project, which generates an analog output signal. This signal is converted to digital format before being sent to the CPU. When the soil moisture level exceeds the defined threshold, the digital output pin (D0) switches to a low state.

3. *DHT11 Sensor module*

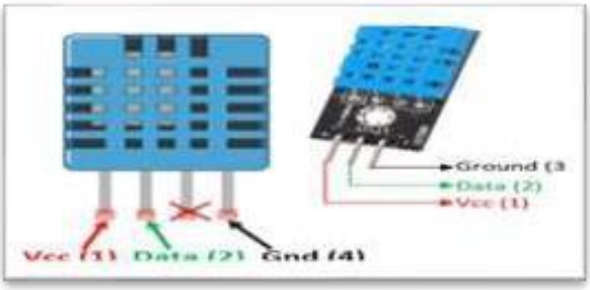

Fig 4: DHT11 Sensor module

Figure 4 shows the DHT11 sensor module, a popular digital sensor for measuring temperature and humidity. It can detect humidity levels ranging from 20% to 90% with an accuracy of ±5%, and temperature from 0 to 50 degrees Celsius with a precision of ±2 degrees Celsius.

4. Relay module

Fig 5: Relay module

Figure 5 displays the 5V Relay module, which allows for the control of AC/DC loads using Arduino, PIC, ARM, and other microcontrollers. This module can switch loads up to 10A and includes both a power indicator LED and a signal indicator LED for easy monitoring.

5. Water pump

Fig 6: Water pump

Figure 6 presents the Mini DC water pump, capable of pumping water to a height of 40-110 cm. This pump operates within a voltage range of 3 to 12V and can be easily controlled using development boards such as Arduino, Raspberry Pi, NodeMCU, and other microcontrollers.

Software Requirements

6. Arduino IDE

Fig.7 Arduino IDE

Figure 7 illustrates the Arduino Integrated Development Environment (IDE), a cross-platform application built using C and C++ functions. It is used to write and upload programs to Arduino-compatible boards and other development boards through third-party cores. Programs created in the Arduino IDE are referred to as "sketches," with each sketch saved under a unique name and a specific file extension.

7. Blynk Application

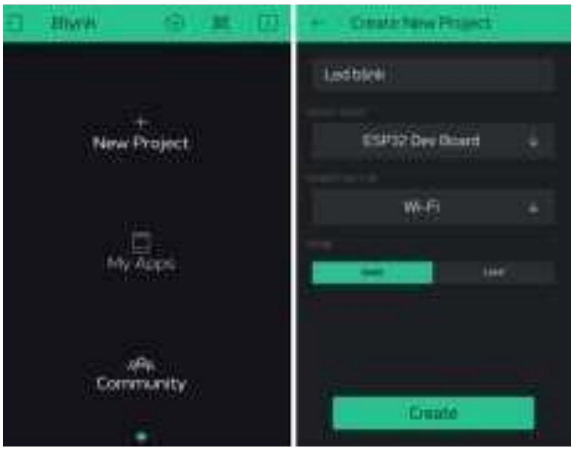

Fig.8 Blynk Application

Figure 8 depicts the Blynk application, a platform that enables control of Arduino, Raspberry Pi, and other devices over the Internet using iOS and Android apps. It features a digital dashboard where you can easily drag and drop widgets to design a custom graphic interface for the project.

IV. IMPLEMENTATION

A. *Circuit Diagram*

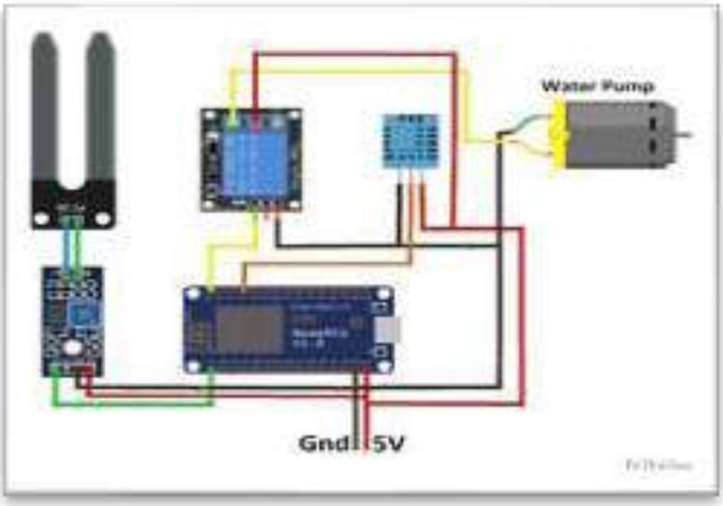

Fig.9 Circuit diagram

Figure 9 illustrates the circuit diagram of the IoT system, which automatically irrigates based on soil moisture levels and sends real-time data to the user's mobile device via the Blynk application to monitor land conditions. The system includes a water pump that activates to irrigate the land according to environmental factors such as moisture, temperature, and humidity, which vary for different crops. When soil moisture falls below a preset threshold, the pump automatically turns on and continues watering until the moisture level reaches the required threshold, at which point the pump switches off. Sensor data is transmitted at regular intervals through the Blynk app, allowing remote monitoring from anywhere in the world. The app also allows users to control water supply for multiple crops and adjust threshold values as needed, offering farmers greater convenience and efficiency.

The Process Flow is as follows:

1. All the connections are made to the NodeMCU as the circuit diagram. A code is written to interface NodeMCU with various sensors.
2. The soil moisture sensor is placed in the soil to measure the moisture content of the soil, if it is below a threshold value then the water pump gets activated to automatically to irrigate the soil. Blynk app is used to control the pump manually.
3. DHT11 sensor is used to acquire the temperature and humidity of the surroundings and an alert is sent if any parameters is found to cross a specified threshold.
4. All the data from the sensors are then sent to the Blynk application, where we can get all the values of various parameters.

V. RESULTS

The following are the results of the suggested system's design and implementation.

Figure 11

Figure 12

1. An automated irrigation system is designed using a nodeMCU.
2. Water pump is activated when the moisture of the soil is low.
3. Real time parameters like the **soil moisture, temperature, humidity, light intensity** required to monitor an agricultural field is visible on blynk app ie shown in figure 11.
4. Manual override to control the water pump when needed. An alert is sent when one of the parameter exceeds a specified threshold ie shown in figure 12. The values of the parameters are sent at specified intervals of time for analysis.

VI. CONCLUSION AND FUTURE SCOPE

This IoT-enabled Smart Irrigation System has proven to be a cost-effective solution for conserving water resources and optimizing them for agricultural productivity. By operating in an automated and intelligent manner, the system supports farmers by delivering water only to the necessary areas of land, using multiple soil sensors. With its low maintenance requirements, the system is accessible to all farmers and contributes to significant water conservation. The use of this method leads to substantial improvements in crop yield. In the future, this system could become even more advanced, potentially predicting user actions, monitoring plant nutrient levels, estimating harvest times, and more. Future advancements incorporating Machine Learning algorithms could further enhance the system, benefiting farmers and reducing water usage in agriculture.

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