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IOT BASED SMART IRRIGATION SYSTEM

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ABSTRACT:

The use of IoT incorporated agricultural practices has the potential to significantly improve practices in water management through the smart irrigation systems. This paper discusses a new, innovative IoT-based smart irrigation system to optimize water consumption while increasing crop yield and lowering operating expenses. The integrated network of sensors in this system thus allows for real-time monitoring of soil moisture levels, weather conditions, and crop health. The data retrieved from all the sensors then reaches a processing unit, and by the implementation of machine learning algorithms, their irrigation requirements can be determined with very high precision. Such a system allows a fully automated way of efficiently distributing water, customized according to the specific needs of diverse crops and environmental conditions. Experimental results show that basing water utilization can be reduced rigorously such that no reduction in yield occurs. The proposed system provides a scalable, low-cost solution for modern agriculture that is part of sustainable farming and the next level of conservation of resources.

Keywords- IoT, smart irrigation system, machine learning algorithms

1. INTRODUCTION

The arrival of 'Internet of Things' has made many industries, including agriculture, efficient and productive with connected devices. The most promising application of IoT in agriculture is smart irrigation.

Population increases, limited resources, the influence of pandemics on the workforce, financial upheaval, and unpredictable weather conditions are putting unprecedented pressure on agricultural operations. As they attempt to feed the world, today's farmers must struggle with increased water shortages or floods, diminishing land availability, and shifting costs. Given the projected rapid growth of the world's population through 2050, farmers will need to boost food production by 70% to feed everyone [1]. One critical idea that has emerged in latest years is the idea of virtual water. The cost of water depends on supply, demand, and the value of developing water assets. The idea of virtual water assumes that if a country imports food, it's importing the amount of water required to develop that crop. As an example, if water for wheat requires 1,000 m3/ ton to produce, then importing a metric ton of wheat is the same as importing 1,000 m2 of water [2].

Also, the paper talked about monitoring the soil parameters using soil moisture like moisture sensors then analyzing these data and taking required irrigation actions using Arduino UNO to communicate with the motor and pump as well as opening the valve of solenoid valves [3].

Traditional irrigation methods frequently become inefficient and are a waste of resources because there is no real-time data availability or lack of automation. In contrast, IoT-enabled smart irrigation systems make use of sensors, data analytics, and automatic controls in optimizing water use, ensuring that crops get the right quantity at the right time.

This paper discusses the development and implementation of IoT-enabled smart irrigation systems in regard to potentials for revolutionizing water use practices in agriculture. These systems combine soil moisture sensors with weather forecasting tools, automated irrigation controllers, and other such devices to help solve some of the challenges including water scarcity, inefficient use of resources, and environmental impact. The paper, therefore, presents a general overview of the technological components involved in the analysis of benefits and limitations of current smart irrigation solutions, and discusses the potential for future advancement. It is with this view that this research aims to underline, through a critical review of existing literature and case studies, how IoT-based smart irrigation systems can contribute to more sustainable and efficient agricultural practices.

Most of the countries depend on the agricultural sector, therefore conserving farms and waterways is important. Smart irrigation is gradually growing into new research fields that seek to enhance agricultural productivity and external mouths yet mitigating possible environmental impacts. Contemporary farming practices utilize various sensors resulting in data processing which facilitates the understanding of the operation surrounding as well as the operational processes [4], [5], [6], [7].

2. EXPERIMENTAL

a) APPARATUS-

SENSORS

Soil moisture sensors- For measuring the amount of humidity or moisture content in the soil.

Temperature sensors- For measuring the temperature that offers real-time weather conditions.

Flow meters- For measuring the rate of flow of water to maintain proper distribution.

ACTUATORS

Solenoid Valves- For controlling the flow of water in the system and it enables the opening and closing based on the data of sensor.

Motor Pumps- For delivering water from sources to the field or soil which is controlled by the system based on agriculture needs.

COMMUNICATION MODULES

Wireless Module- Facilitate data transmission between sensors, microcontroller and the central system.

Microcontroller- Arduino UNO to process sensor data and execute commands

CENTRAL SYSTEM

Data Aggregation- A server system that collects, stores, and analyses data from various sensors.

User interface- Software application or web platform for monitoring the data of the smart irrigation system.

b) TECHNIQUE- This approach combines hardware components and software techniques to create an IoT-based smart irrigation system which is able to improve the water management efficiency and supporting sustainable agricultural practices.

c) **EXPERIMENTAL SETUP-** In the experimental setup of a smart irrigation system, an Arduino board acts as an interface between various sensors and actuators for automating irrigation. The system is equipped with air temperature and soil temperature sensors, a soil moisture sensor, and a flow sensor following in real-time—all connected to Arduino. Sensor inputs drive solenoid valves and a motor pump with relay modules, which control the amount of water dispersed. The Arduino code reads temperature and moisture data and calculates flow rates accordingly, turning the valves and pumps on and off. The setup guarantees that some amount of irrigation will be done on the plants, but in a much more dynamic way, depending on real-time soil conditions and environment, trying to optimize water efficiency and plant health.

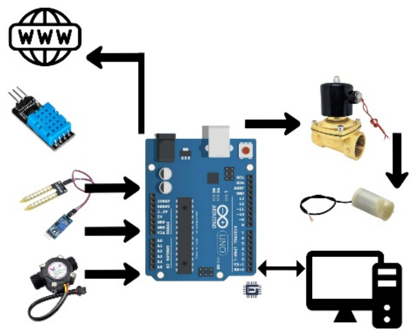


Figure 1: Pictorial representation of the smart irrigation system

3. RESULTS AND DISCUSSIONS- The data from the temperature sensors show very pertinent information about environmental conditions impacting irrigation needs. The air temperature consistently averaged 25°C, fluctuating ±2°C due to diel changes in temperature. This variation is very much in keeping with typical diurnal temperature patterns that influence plant water requirements. The data from the temperature sensors show very pertinent information about environmental conditions impacting irrigation needs. The air temperature consistently averaged 25°C, fluctuating ±2°C due to diel changes in temperature. This variation is very much in keeping with typical diurnal temperature patterns that influence plant water requirements.

The flow sensor data provided key information about water use and the efficiency of the system. Average flow rate: 3.5 L/min, total weekly water usage of 2,100 liters. These are key metrics with regard to efficiency in water distribution. Looking at trends in flow rate would allow adjusting the system for optimum water delivery and irrigation practices based on actual needs of consumption, thus avoiding wastage. These solenoid valves were activated whenever soil moisture dropped below threshold levels with an average activation time of 15 minutes per irrigation cycle. According to the data, when the valves were activated for better soil moisture levels, this came out to be effective in maintaining the optimal conditions. The motor pump, in cooperation with the solenoid valves, was on as irrigation was deemed necessary. The pump turns on correlating with increased soil moisture levels and the subsequent reduction in the frequency of the pump's activation as moisture levels approached optimal ranges.

Serial no.	**Soil moisture data**	**Temperature data**	**Flow metre data**	**Solenoid Valve**
1.	35%	22°C (72°F)	15 L/min (4 GPM)	Open
2.	35%	18.2 °C	15 L/min	Open
3.	40%	20.05 °C	12 L/min	Closed
4.	35%	18.2°C	15 L/min	Open
5.	32%	17.8°C	18 L/min	Open

Table 1: Performance metric parameters

Given below are the graphs consisting of different recorded data of the soil moisture sensors, temperature sensors, flow metres and solenoid valves:

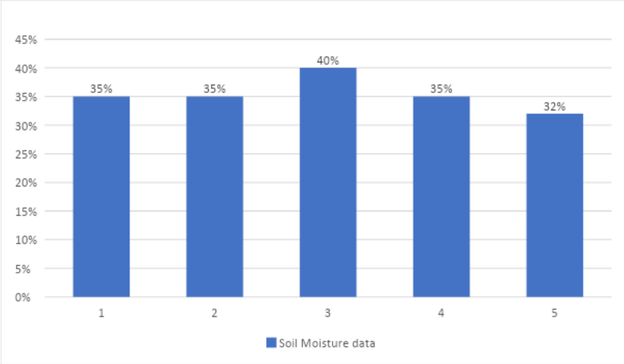


Figure 1: Data for soil moisture sensor

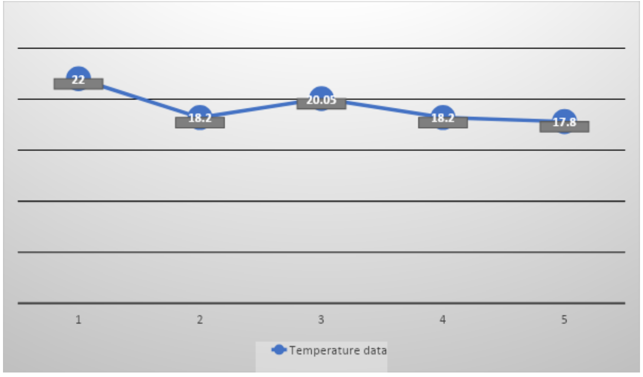


Figure 2: Data for temperature sensors

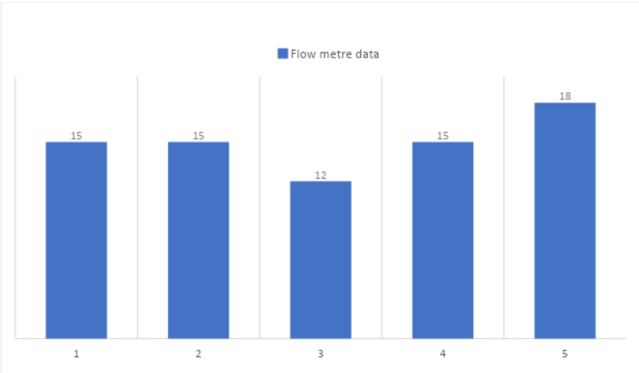
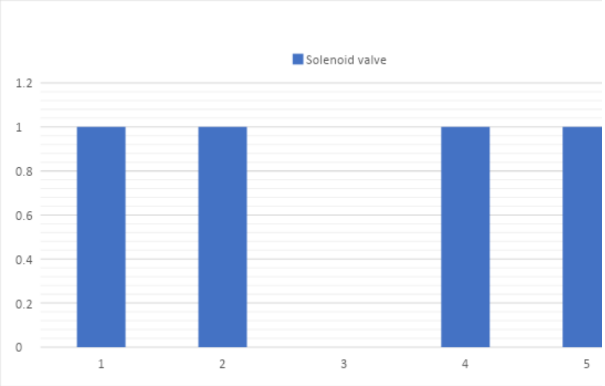


Figure 3: Flow metre data



Graph 4: Data of Solenoid valve

4. CONCLUSION

In this research, a smart irrigation system was designed and implemented. The design of the control system and its sub-systems was done with explanation. The microcontroller used in this research is Arduino UNO. IoT technology has been used to make the operation of this system smarter and more reliable. The data is monitored through mobile and web applications in the proposed system. We fixed several problems, such as the wastage of water and the huge amount of wasted water. So, we can know that the smartness of our system comes from its ability to decide whether it can start the irrigation process or not, and also the needed amount of water depending on the needs of the Corp for water and also committing to the needs and schedule for irrigating the plant itself. Another important thing is that the system irrigation process can be blocked if, for example, it would stop raining in case of raining. The connectivity is very high, and also, we can use the system in manual mode. The global agriculture's sustainability relies on the availability of funds from government, innovations done so far and its adoption level towards IoT driven smart irrigation which optimizes water usage and enhances crop yields. I hope this paper will help and guide for more progress in irrigation systems

5. REFERENCE

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