Article ID 240202003

IoT Enabled Intelligent Drip Irrigation System for Small-Scale Vegetable Cultivators

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For the majority of Indians, agriculture is a means of subsistence. The expansion of our nation is mostly attributable to the agricultural sector. The necessity for an effective method to control field irrigation has arisen due to changing environmental circumstances and water scarcity. There has not been a notable improvement in agricultural output despite numerous groundbreaking innovations in the field. Important elements impacting agricultural output include inadequate irrigation infrastructure and a lack of agricultural expertise. The impact of these issues, however, can be mitigated through the use of modern agricultural machinery. The majority of Sikkim's agricultural output is dependent on the monsoon rains. There is a missed opportunity to grow high-value horticultural crops in this area due to the absence of infrastructure for irrigation and water storage.

Definition and importance of IoT in Agriculture

The term "Internet of Things" (IoT) is used to describe a system of interconnected computing devices, wherein everyday items are equipped with sensors, software, and other technologies to facilitate data exchange and connection with other systems and devices through the internet. One of the key goals of the Internet of Things (IoT) is to facilitate high-level communication between various objects, systems, and services through the incorporation of various protocols, domains, and technological components.

IoT based Smart Irrigation system

The IoT-based Irrigation System not only automatically irrigates the soil based on moisture levels, but it also sends data to a dedicated server to monitor the land's status. The IoT-based Smart Irrigation system promises to boost crop productivity through the use of an intelligent irrigation controller and wireless sensors. Sensors monitor basic characteristics such as soil moisture, pH, temperature, and humidity. Irrigation decisions are made based on sensed data and the crop being cultivated. The technology includes a smartphone application that allows farmers to remotely monitor and control the irrigation system.

Topography, climate and agriculture scenario of Sikkim

Sikkim is one of India's smaller hilly states, located in the northeastern region. It is located between 27°04'46" to 28°07'48" N latitudes and 88°00'58" to 88°55'25" E longitudes and covers an area of 7096 sq. km. The state's geography is hilly, with elevations ranging from 300 to 8586 metres. Approximately 60% of the land area is over 3000 metres. The state's economy is predominantly agrarian, with agriculture providing a living for more than 64% of the people. Sikkim has around 1,09,000 hectares of agricultural land, accounting for 15.36% of the total geographical area. The agricultural climate varies from subtropical to alpine. Mixed farming is prevalent throughout the state. Altitudinal changes allow for the cultivation of various grains, pulses, vegetables, fruits, and flowers, but production and productivity are significantly lower than in other parts of the country for a variety of reasons. The region receives an appropriate amount of rainfall, but it is heavy and unevenly distributed from May to early October. Rainfall declines or ceases in October, and the entire state endures a dry winter season with little or no precipitation from December to March. As a result of the drying or significant reduction in spring discharge, there is an acute drinking water deficit throughout the winter months. Even though water is accessible in the valleys, geographical limits cause a considerable number of agricultural areas to rely solely on rainwater.

Proposed IoT-based automatic drip irrigation system

Figure 1 shows the suggested block diagram for IoT-based automatic irrigation, which includes all of the layers stated above. Details related to management and security should also be examined.

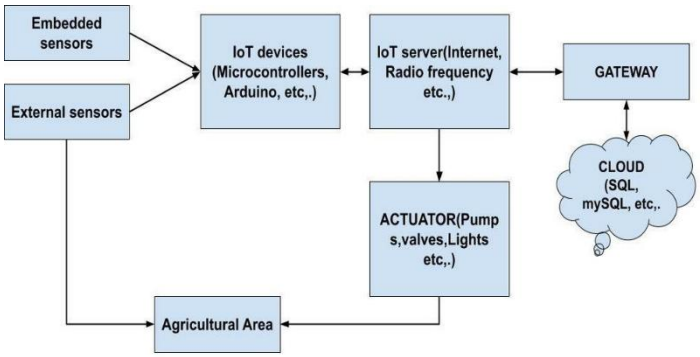

Fig. 1. Proposed architecture for IoT-based automatic irrigation system

The primary components of this system are the actuator, supervisory, and sensor nodes, which communicate with one another. Soil moisture sensors at each node collect data on soil moisture levels and relay that data to the node in charge of supervision. The actuator node is set to automatically turn on or off when the moisture content reaches or exceeds a certain threshold. The supervisory node controls the actuator node and also keeps information on its SD card. A solenoid valve linked to the primary water tank is part of the actuator node. When the soil moisture level is low, the valve opens, and when it's high, it closes. Thus, the system can be operated either manually or automatically.

Design and Implementation of IoT based drip irrigation system

Wireless sensors were used to create an IoT-based autonomous gravity drip irrigation system for the polyhouse environment. It employs capacitive soil sensors, which not only detect moisture content in the soil but also aid in the identification of various soil characteristics such as water retention capacity. To detect the time taken by sensors so that they can determine the duration of irrigation. This approach takes into account the fact that various plants consume varying quantities of water during different seasons. Sensor nodes use NRF24L01 to communicate with the wireless station. The suggested system is intended to generate power from solar energy. The charge controller is installed between the battery and the solar panel to prevent power from flowing back to the panel, regulate power flow, and prevent the battery from being overcharged. The charge controller transfers energy to the entire device.

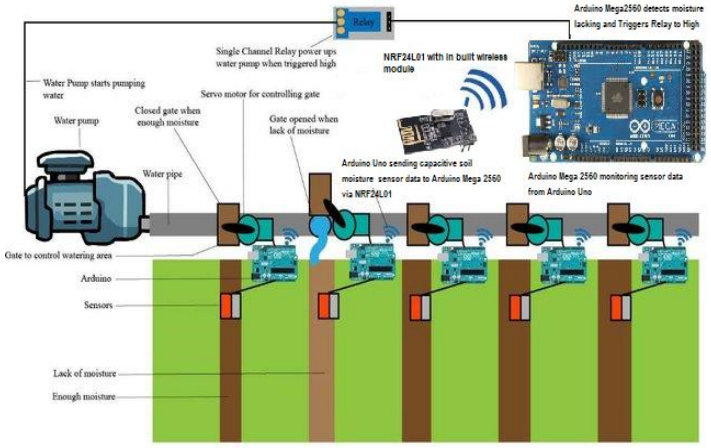

Fig. 2. Schematic of IoT- based drip irrigation system

The system's fundamental component is the control unit. It is made up of an Arduino Mega 2560 microcontroller, which serves as the system's brain and regulates all of the attached gadgets. The suggested system is comprised of a single Arduino Mega 2560 microprocessor, an Arduino Uno, relay modules, water tank, solenoid valve, and capacitive soil sensors (figure 2). The sensors are positioned in different ways close to the drip line. The temperature, humidity, and moisture content of the soil are measured by the Arduino and compared to a preset threshold value. The micro-controller uses the relay that is linked to activate the solenoid valve if the data it receives from the soil are outside of the intended, restricted range.

Fig. 2. Field view of IoT- based drip irrigation system inside the polyhouse

Three Arduino sensors are installed throughout the polyhouse to collect data. An Arduino Uno and NRF24L01 are linked to a solenoid valve near

the water tank. The Arduino MEGA 2560 decides whether or not to deliver water based on the data it receives. If there is a lack of moisture, the Arduino MEGA 2560 instructs the relay module to activate/switch on the water pump and open the solenoid valve for a set period of time, after which it deactivates/switches off the solenoid valve. Water is pumped through a drip to a specified region, not the entire land area. Figure 3 depicts the field view of an IoT-based drip irrigation system within the polyhouse.

Advantages

- **Water Conservation:** Efficient and sensor-based irrigation system helps to save the water due to measured and timely application of irrigation water
- **Real Time Data:** It helps to record/receive the real time data for proper application
- **Lowered operation cost:** Operation cost is lowered due to less requirement of field manpower
- **Efficient and saves Time:** Sensor based drip irrigation system is very efficient requires very low power and save time in irrigating the field.
- **Increase in productivity:** Increased yield and quality of produce.

Disadvantages

- **Complexity:** The IoT is a set of diverse structure and complex network
- **Privacy/Security:** Privacy and security issues may arise sometimes
- **Initial investment:** IoT based irrigation system requires initial investment
- **Awareness and Training**: it is necessary to create awareness among the farmers

Conclusion

Especially in hilly places, rainfall is insufficient from September to April, and soil has a very low water retention capacity. One of the most serious issues that farmers in hilly areas confront is that the terrain is rugged and difficult to navigate. Thus, an IoT-based autonomous drip-irrigation system is required that will carefully monitor and control field requirements even in the steep terrains of India's North-East area. Sensors are required to collect data, which is essential for a real-time irrigation management system. The IoT-based autonomous drip irrigation system for greenhouse is feasible and cost-effective, saving time and ensuring optimal water consumption for agricultural purposes.

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