Smart Irrigation System For Agriculture Based On Wireless Sensor Network And IOT

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Abstract

Efficient water management is crucial for sustainable agriculture, especially in regions facing water scarcity. This paper presents a smart irrigation system that leverages wireless sensor networks (WSN) and Internet of Things (IoT) technologies to optimize water usage in agricultural practices. The proposed system integrates various sensors and IoT devices to monitor soil moisture levels, weather conditions, and crop health, providing real-time data to manage irrigation processes more effectively. Agriculture is one of the industries which have recently diverted their attention to wireless sensor networks. Wireless sensor networks have been widely used in monitoring agriculture and collecting data such as agricultural irrigation, fertilization, pest control, greenhouse cultivation, and livestock breeding. This paper presents a primer on the applications of wireless sensor networks technology in agriculture. Keywords: Precision Agriculture, Green/Sustainable Agriculture, Digital Agriculture, Smart Agriculture.

An IoT sensor, short for Internet of Things sensor, is a mechanism embedded in a physical device to collect data from its surrounding environment. These sensors transfer the gathered data to other devices or systems over the internet. Various sensor types, such as pressure, temperature, sound sensors, etc. collect data in diverse environments. The effectiveness of these sensors depends on their type and quality, making them suitable for different applications.

In order to resolve the problems which include loss of soil fertility and waste of water resource in agriculture production, we design an intelligent irrigation system based on wireless sensor networks and fuzzy control. The system mainly consists of wireless sensor networks and the monitoring center. All of the nodes in Monitoring area use solar power collect the information of soil moisture, together with the growth information of different crops in different periods. Soil moisture content deviation and the rate of change of deviation are taken as input variables of fuzzy controller, and the fuzzy control regular database is established for the fuzzy irrigation control system. The monitoring center receives the data transmission from wireless sensor network node, and output information of irrigation water demands to the relay via a wireless sensor network to control opening and closing time of the valve in crop areas. The experimental results show that the system has a stable and reliable data transmission, which achieve real-time monitoring of soil on crop growth, give a right amount of irrigation based on crops growth information, which has broad application prospects.
Keywords: Smart Irrigation, Agriculture Technology, Wireless Sensor Network (WSN), Internet of Things (IoT), Soil Moisture Sensors, Environmental Sensors, Remote Monitoring, Automated Irrigation etc.

I. Introduction

Agriculture plays an important role in many countries and is the backbone of the economy in most countries. It has played a crucial role in the development of human civilization. Modern agriculture requires technological tools that can improve production efficiency, meet the increasing demand of food, and reduce their environmental impact. To achieve this goal, new technologies and solutions are being applied in agriculture. One of the key solutions is precision agriculture. As its name implies, precision agriculture is precise in both the size of the crop area it monitors as well as in the delivery amounts of water, fertilizer, etc. Wireless sensor networks (WSNs) are the enabling technology for efficient and inexpensive precision agriculture (PA). WSNs are used to collect, monitor, and analyze data. They can help monitoring fields, thus helping farmers to increase crop production and prevent damages to their crops. A wireless sensor network consists of a series of small low-cost, low-energy, easily-deployable sensors. A WSN system (wired or wireless) may be used to monitor and collect data such as light, humidity, air/water temperature, air pressure, sprinkler water flow, soil acidity, and soil moisture parameters in the agricultural domain. A wireless sensor network (WSN) usually consists of a large number (hundreds or thousands) of sensor nodes deployed over a geographical region. The wireless sensor nodes are compact, light-weighted, and battery-powered devices that can be used in virtually any environment. The sensor nodes monitor physical or environmental conditions such as temperature/heat, humidity, sound, vibration, pressure, light, object motion, pollutants, presence of certain objects, noise level or characteristics of an object such as weight, size, speed, direction, and its latest position. The sensor node is made up of four components: a power unit, a transceiver unit, a sensing unit, and a processing unit. The node may also have some application-dependent components. Specific sensors commonly used include air temperature, relative humidity, light, soil moisture, and soil temperature.

A substantial amount of water is lost to evaporation, wind and runoff as a consequence of improper watering methods. Reducing or eliminating this loss decreases utility bills and creates a more water efficient, healthy landscape. Outdoor water savings can be achieved using smart irrigation technologies. Smart irrigation controllers and sensors have been developed to reduce outdoor water use by irrigating based on plant water need compared to traditional automatic system timers, which irrigate on a user-determined fixed schedule. This technology exists as a complete controller or as a sensor that can be added to an existing irrigation timer to create a smart controller. Smart irrigation technology uses weather data or soil moisture data to determine the irrigation need of the landscape.

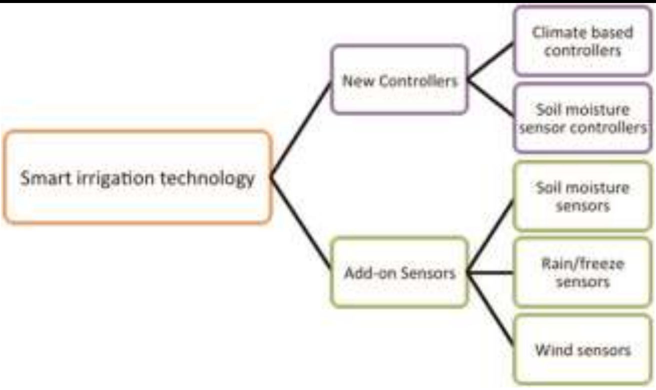
Rainfall in Oklahoma is variable across the state and fluctuates by year. During dry periods, irrigation may be needed to preserve landscape quality. Over- or under-irrigating a landscape can possibly increase disease incidence, waste water and decrease overall landscape condition. Irrigation system efficiency is dependent upon several factors including design, installation and specific site conditions. Water applied to a landscape can account for a significant portion of a property's water use. In Oklahoma, outdoor water use accounts for approximately 30 percent to 50 percent of household water use.

These products maximize irrigation efficiency by reducing water waste, while maintaining plant health and quality. Incorporating smart irrigation technology in the landscape can potentially reduce outdoor water consumption. This technology is appropriate for small, residential landscapes as well as large, managed landscapes. The following sections describe how each product functions and the advantages and disadvantages of each product. Irrigation managers and homeowners should be aware that smart irrigation technology will need to be periodically adjusted and maintained for maximum water savings.

Discussion

For centuries, Agriculture has been either heavily weather-driven or instinctive. The result is perpetual crop yield and quality concerns, increasing investments and reducing profits. But the introduction of technologies like AI, IoT, etc., is helping farmers mitigate farming risks and positively contribute to agricultural yield, Informed decisions, And smart irrigation. Water scarcity has been a concern for Indian farmers throughout. Depleting groundwater resources, Reducing rainfall, And uneven water distribution are all together massively contributing to the current plight of farmers in India.

Not to forget, tactical problems on the ground, like poor quality of pipes, leakages, and untimely irrigation schedules, which lead to water wastage and affect soil moisture content. In many cases, farmers have been found to be buying water to complete the water needs of their crops, thus increasing the overall farming investment. If farmers focus on sustainability, They will realize that the key to growing more and a better yield is not buying more resources. Technologies like IoT can be of significant help in this regard. They can enable farmers to automate irrigation **systems** and help them derive better results. Ensures efficient water and nutrient supply. Automated operations help save efforts and labor resources. Farmers don't have to step out every time to operate the irrigation system. The IoT system can enable farmers to analyze the soil moisture content, crop growth phase, and corresponding water requirement. Thus, it can help them make informed and data-driven irrigation decisions. Irrigation takes place on time and only for the required time. The system delivers the right amount of water and nutrients directly to the plant's root zone at the right time. Precision supply reduces water and nutrient use and wastage.



There is a broad spectrum of smart irrigation technology that consumers can benefit from utilizing. Choosing the correct technology for the situation is essential to achieve potential water savings. Watering restrictions exist in some areas of Oklahoma, so the irrigation timer may be adjusted for allowed watering days. Irrigation controllers can be separated into two main categories: Climate based controllers and soil moisture based controllers.

Climate-based controllers also referred to as evapo transpiration (ET) controllers use local weather data to adjust irrigation schedules. Evapo transpiration is the combination of evaporation from the soil surface and transpiration by plant materials. These climate-based controllers gather local weather information and make irrigation run-time adjustments so the landscape only receives the appropriate amount of water. Evapo transpiration controllers have been shown to reduce outdoor water use. In Las Vegas, Nev., homes with ET based controllers saw an average of 20 percent irrigation reduction compared to homes with homeowner-scheduled irrigation. Additionally, a study conducted on St.

The second type of smart irrigation controllers includes soil moisture sensor controllers. Instead of using weather data, soil moisture sensor controllers utilize a soil moisture sensor placed belowground in the root zone of lawns to determine water need. The soil moisture sensor estimates the soil volumetric water content. Volumetric water content represents the portion of the total volume of soil occupied by water. The controllers can be adjusted to open the valves and start irrigation once the volumetric water content reaches a user-defined threshold. The appropriate threshold value depends on soil and vegetation type and usually ranges from about 10 percent to 40 percent.

In many cases, a scheduling irrigation controller is already in use on a property and upgrading to a smart controller is impractical. To increase efficiency of automatic irrigation systems soil moisture, rain, wind or freeze sensor can be added to upgrade the existing system. Some manufacturers produce devices capable of measuring multiple environmental elements using one apparatus. Many sensors are compatible with existing systems, easy to install and produce similar results to smart irrigation controllers. The add-on sensors are generally more affordable than smart irrigation controllers, assuming a compatible irrigation timer is already installed on site.

Soil moisture sensors can be connected to an existing irrigation system controller. The sensor measures the soil moisture content in the root zone before a scheduled irrigation event and bypasses the cycle if the soil moisture is above a specific threshold. Different types of soil moisture sensors are available and the consumer should ensure system compatibility before purchasing a sensor. Some soil moisture sensors include a soil freeze sensor that will interrupt the irrigation cycle if temperatures fall below 32 F. Soil moisture sensors are available as wired or wireless systems. Typical cost for a soil moisture sensor can range from $99 to $165.

Although these sensors are not considered smart technology, rain and freeze sensors interrupt the irrigation cycle during a rain or freeze event when irrigation is unnecessary. Watering during the rain wastes water, money and causes unnecessary runoff. Three different types of rain sensors are available and each function is based on separate concepts.

The original type of rain sensor still in use today works with a small cup or basin that collects water, once a pre-determined amount is collected, the weight of the cup interrupts the irrigation cycle (Figure 4). Debris in the cup can also interrupt the irrigation cycle and should be checked and cleared of litter periodically.
The second type of rain sensor uses a dish with two electrodes that are a specific distance from the bottom of the cup. The distance can be adjusted to allow for small rain events and similar to the first type of rain sensor, debris can reduce accuracy by displacing water in the cup. When the water reaches the electrodes, the irrigation cycle is interrupted. The third type of rain sensor does not have a rain catch cup, which makes it low maintenance and reliable. Instead, the sensor uses several disks that expand as they get wet (Figure 5). The expanded disks trigger the switch and interrupt the cycle. The system will resume the scheduled cycles once the disks dry out. The disks should be checked at least once a year to determine if they need to be replaced. All of the devices should be mounted in an open area where they will receive rainfall.

Potential water savings depends on the amount of rainfall in any given year. During years with average to above average rainfall, water savings are more significant than during dry years. Rain sensors have shown payback periods of less than a year, but should be monitored for optimum performance.

As an example, if a homeowner's irrigation system waters a ¼-acre yard and applies 1 inch of water each irrigation cycle, then each cycle applies 6,789 gallons of water. If water costs $5.00 per 1,000 gallons, the monetary savings will be $33.95 each time the irrigation cycle is interrupted during a rainfall event. Considering each rainfall event, the homeowner could expect substantial water and money savings. Most wireless rain sensors are more expensive and range from $120 to $200, while wired rain sensors cost approximately $30 to $50.

Freeze sensors interrupt an irrigation cycle when air temperatures fall below 32 F. Eliminating irrigation during freezing temperatures can potentially extend irrigation system life and prevent sidewalks and streets from icing over, causing dangerous situations. Many rain sensors include a freeze sensor and homeowners should account for sensor capability when considering price.

Future work

The system architecture includes a network of wireless sensors distributed throughout the agricultural field, each equipped to measure soil moisture, temperature, and humidity. These sensors transmit data to a central gateway through a low-power, wireless communication protocol. The gateway processes the collected data and sends it to a cloud-based platform via IoT connectivity. The platform uses advanced algorithms to analyze the data, generate actionable insights, and control irrigation systems automatically.

Key features of the smart irrigation system include:

- Real-time monitoring of soil moisture and environmental conditions to determine optimal irrigation schedules.
- Automated irrigation control based on data-driven insights, reducing water wastage and improving crop yield.
- Remote access to irrigation controls and data through a user-friendly mobile or web application, allowing farmers to manage their irrigation systems from anywhere.

The paper discusses the design, implementation, and integration of the wireless sensor network and IoT components. It addresses challenges such as ensuring data accuracy, managing network reliability, and optimizing energy consumption for sensor nodes.

Preliminary field tests demonstrate that the smart irrigation system significantly improves water use efficiency and crop productivity compared to traditional irrigation methods. The system's ability to provide precise, data-driven irrigation decisions offers substantial benefits for sustainable agriculture.

Future work will focus on enhancing system scalability, incorporating additional sensors for more detailed environmental monitoring, and integrating machine learning algorithms to further refine irrigation strategies based on evolving conditions and historical data.

Future Scope

The future scope of smart irrigation systems based on wireless sensor networks (WSN) and Internet of Things (IoT) encompasses several areas of advancement and expansion. These developments aim to enhance the system's efficiency, scalability, and integration with broader agricultural practices:

Develop more advanced sensors with higher accuracy and greater longevity to measure additional parameters, such as soil nutrient levels, crop growth stages, and weather forecasts. Explore new sensor technologies, such as remote sensing and satellite-based imagery, to complement ground-based measurements and provide a more comprehensive view of field conditions. Integrate the smart irrigation system with other precision agriculture technologies, such as drones, automated machinery, and crop management systems, to create a holistic approach to farm management. Use data from multiple sources to enhance decision-making and optimize overall farm operations, including planting, fertilization, and pest control. Implement advanced data analytics and machine learning algorithms to predict irrigation needs based on historical data, weather patterns, and crop requirements. Develop predictive models to anticipate water needs, detect early signs of crop stress or disease, and optimize irrigation schedules dynamically. Design systems that can scale easily to accommodate various field sizes and types of crops. This includes modular components that can be added or adjusted based on specific needs. Develop solutions for both large-scale commercial farms and smallholder farmers, ensuring that the technology is accessible and affordable for diverse agricultural settings.

Explore energy-efficient technologies and renewable energy sources, such as solar-powered sensors and irrigation systems, to reduce the environmental impact of the smart irrigation system. Implement low-power communication protocols and energy-harvesting techniques to extend the operational life of wireless sensors. Enhance user interfaces to provide intuitive, real-time data visualization, alerts, and control options. This includes developing mobile apps and web platforms with easy-to-use features. Enable remote management and automation capabilities, allowing farmers to control irrigation systems and access data from anywhere using internet-connected devices. Integrate real-time climate and weather data into the irrigation management system to better account for factors such as rainfall, temperature fluctuations, and humidity. Develop algorithms that adjust irrigation schedules based on predicted weather patterns and climate forecasts. Ensure that the smart irrigation system complies with relevant agricultural and environmental regulations and standards. Contribute to the development of industry standards for smart irrigation systems to promote interoperability and ensure consistency across different platforms and technologies. Conduct extensive field trials in diverse geographic and climatic conditions to validate the system's performance and reliability. Gather feedback from farmers and stakeholders to refine the system, address practical challenges, and enhance user satisfaction. Provide educational resources and training programs to help farmers understand and effectively utilize the smart irrigation system. Develop support services, including technical assistance and troubleshooting, to ensure successful implementation and operation. By focusing on these areas, future advancements in smart irrigation systems can significantly improve water management, enhance crop productivity, and contribute to sustainable agricultural practices worldwide.

Conclusion

The proposed system relies on a model that monitors and controls soil and weather characteristics using a set of sensors deployed in agricultural land and improves making the decisions for the rational use of water in irrigation, and thus saving water, raising the performance of irrigation systems, reducing costs needed, and increasing the efficiency of production. When the size of WSN increases (i.e., more sensors are added), the power consumption becomes very important, and thus the lifetime of the network is decreased. In future works, we will look for optimal solutions to minimize energy consumption. Also, we will approach the point of security where we will try to secure measured data using improved solutions of data encryption.

Reference

[1] J. S., Su, Y. W., Shen, C. C., 2007. A comparative study of wireless protocols: Bluetooth

[2] Bhattacharyya, D., Kim, T. H., Pal, S., 2010. A comparative study of wireless sensor networks and their routing protocols. Sensors, 10 (12), 10506- 10523.

[3] N. M., 2002. The role of irrigation in food production and agricultural development in the Near East Region. Journal of Economic Cooperation

[4] FAO, IFAD, UNICEF, WFP and WHO. 2018. The State of Food Security and Nutrition in the World 2018: Building climate resilience for food security

[5] Kim, Y., Evans, R. G., Iversen, W. M., 2008. Remote sensing and control

[6] R. K., Rawat, N., Boppana, L., 2014. WSN sensors for precision agriculture. I

[7] Manshahia, M. S., 2016. Wireless sensor networks: a survey. International Journal of Scientific

[8] Mishra, A. K., Singh, V. P., 2010. A review of drought concepts. Journal of hydrology,

[9] Rehman, A., Abbasi, A. Z., Islam, N., Shaikh, Z. A., 2014. A review of wireless sensors and networks'

[10] Rijsberman, F. R., 2006. Water scarcity: fact or fiction?. Agricultural water management, 80 (1-3), 5-22.

[11] Wi-Fi Alliance Organization, Official industry association Web site. [Online]. Available on: https://www.wifi.org/, accessed August 2018.

[12] Wang, C., Jiang, T., Zhang, Q., 2016. ZigBee® network protocols and applications

[13] https://extension.okstate.edu/fact-sheets/smart-irrigation-technology-controllers-and-sensors.html#:~:text=The%20soil%20moisture%20sensor%20estimates,reaches%20a%20user%2Ddefined%20threshold.

[14] https://www.mouser.in/applications/smart-agriculture-sensors/#:~:text=Reducing%20chemical%20use%20by%20pinpointing,Maximizing%20water%20use%20efficiency

[15] https://neptjournal.com/upload-images/(52)B-3942.pdf

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