

Smart Agriculture: Enhancing Farm Efficiency with IoT Monitoring and Control Systems

¹L. Nagamani, ²Y. Bhargav, ³B. Krupal, ⁴K. Madhavi, ⁵CH. Sravan,

⁶CH. Lalith Kumar

¹Asst. Professor & ²Professor, Department of Mechanical Engineering

St. Martin's Engineering College, Dhullapaly, Secunderabad – 500100.

^{2,4,5,6} Students, Department of Mechanical Engineering, St. Martin's Engineering College,
Dhullapaly, Secunderabad

Email: manilekhya@gmail.com

Abstract:

In today's digitally dominated landscape, only a select few devices like PCs and mobile phones remain unconnected to the internet. The pervasive influence of the internet and the Internet of Things (IoT) is undeniable, catering to the fundamental needs of humanity. IoT, essentially a network of physical objects embedded with electronics, sensors, software, and connectivity, enables the monitoring and interconnectivity of devices, leading to enhanced value and services through data exchange. By allowing remote sensing and control over network infrastructure, IoT fosters improved accuracy, economic benefits, efficiency gains, and reduced human intervention. This paper explores the foundational concepts of IoT and its future prospects, highlighting its indispensable role in various daily applications. Emphasizing its transformative impact, particularly in agriculture, the study delves into the necessity of IoT and offers insights into its workings. In this paper is IoT's contribution to modern farming practices, exemplified through an Automatic Watering System. This system, utilizing the ESP8266 WiFi Module as a microcontroller, monitors and regulates soil moisture levels to maintain optimal conditions for plant growth. Equipped with temperature, moisture, and humidity sensors, the setup ensures precise irrigation, mitigating the risks of over or under-watering.

KEYWORDS: *IoT-Based Monitoring System, Sensors*

1.0 Introduction

Smart irrigation systems have emerged as a game-changer in the agricultural landscape, paving the way for a more efficient, data-driven, and sustainable approach to crop cultivation. By integrating advanced components such as soil moisture sensors, automation, and remote monitoring, these systems empower farmers with a comprehensive solution to optimize irrigation processes. As the agricultural sector grapples with the need to maximize yields while minimizing resource wastage, smart irrigation systems offer a panacea for a multitude of challenges. The core of these systems lies in their ability to gauge the moisture content of the soil in real-time. Soil moisture sensors, coupled with automation, allow for precise control of irrigation, ensuring that crops receive the perfect amount of water needed for healthy growth. This level of precision leads to tangible benefits: conserving water resources by avoiding over-irrigation, enhancing crop yields, and streamlining labor costs. Smart irrigation systems not only conserve water but also bolster crop quality and overall farm productivity. Automation allows farmers to remotely control and monitor the irrigation process. This translates to considerable savings in terms of time and manpower. Additionally, by minimizing the human element in irrigation, the potential for human error is greatly reduced, contributing to more consistent and reliable crop management. They not only conserve water but also reduce the environmental impact of excessive irrigation, which can lead to soil erosion and nutrient runoff. By collecting data on soil moisture levels, weather conditions, and other relevant parameters, farmers can make informed decisions on when and how much to irrigate. This data-driven approach to agriculture leads to more efficient resource allocation and reduced waste. It also helps in adapting to changing weather patterns and environmental conditions, which are increasingly unpredictable due to climate change. Farmers can access real-time data and adjust irrigation settings from their smartphones or computers, regardless of their physical location. This level of control and flexibility is particularly advantageous in responding to sudden weather changes or crop-specific needs. This also means that agriculture can be managed more efficiently, which is especially critical in large-scale farming operations. These systems employ various power sources, such as batteries or solar panels, to provide a continuous and dependable power supply, enabling the system to function effectively. These systems can collect and analyze data from various sources, including soil moisture sensors, weather forecasts, and historical data, to make informed irrigation decisions. The systems represent a significant step towards efficient, data-driven, and sustainable

food production. They are a testament to the power of technology in revolutionizing agriculture and addressing the evolving needs of our planet.

2.0 Methodology

2.1 Assemble Hardware:

To start the process of creating the Agribot, a smart agriculture robot, you should begin by securely mounting the servo motor onto the chassis. This step is crucial to ensure the motor's stability. Following this, it's essential to set the servo angle precisely to 90°, a critical adjustment that directly impacts the soil moisture sensor's functionality. This sensor should be strategically placed in a location where it can easily collect data on soil moisture levels, as this is one of Agribot's primary functions. Before finalizing the installation of the sensor, it's highly advisable to perform a thorough test to validate its functionality. Once you've confirmed that the sensor is working as intended, connect it to the device using jumper cables. To facilitate precise measurements of soil moisture levels, consider creating a soil moisture tester, which will contribute to Agribot's effectiveness in monitoring and managing soil conditions.

2.2 Connect Servo Motor and Soil Moisture Sensor:

Connect Servo Motor and Soil Moisture Sensor: Creating a functional connection between the servo motor and the soil moisture sensor is a crucial step in the process of building the Agribot, our smart agriculture robot. This connection is the backbone for collecting precise data on soil moisture levels. By successfully linking these components, we enable the Agribot to accurately gauge the soil's moisture content, a pivotal factor in determining when and how much to irrigate the plants. This connection, while seemingly technical, is what empowers the Agribot to operate as an effective autonomous irrigation system, ensuring that plants receive the right amount of water precisely when needed, thereby contributing to healthy and thriving gardens.

2.2 Turn it into an Automatic Irrigation System:

The automatic irrigation system at the core of this technology plays a crucial role. It constantly monitors soil moisture, initiating the water pump when dry conditions are detected, ensuring plants receive adequate hydration. The system operates efficiently, promptly deactivating the

water pump once the soil moisture returns to the desired level. This approach streamlines the process of plant care and promotes responsible water usage, making it an ideal solution for modern, efficient agriculture.

2.3 Make a Water Storage Tank:

To facilitate efficient irrigation, a crucial step involves the creation of a dedicated water storage tank. This tank serves as a reservoir for the water required to nourish the plants. Additionally, to ensure precise and controlled water distribution, a 20-watt pump is securely attached to the system. The integration of a water pump allows the Agribot to regulate the amount of water delivered to the plants, ensuring that they receive just the right amount of hydration for optimal growth. This combination of a water storage tank and a water pump forms an integral part of the Agribot's automatic irrigation system, enabling it to maintain the ideal soil moisture levels and support healthy plant development.

2.4 PowerUp the Agricultural Robot:

To power the Smart Irrigation Robot effectively and ensure a reliable and portable energy source, a 12V DC lipo battery is connected. This battery serves as the essential powerhouse for the agricultural robot, enabling it to perform its automated tasks efficiently. To ensure stability and secure functionality, the battery is securely fastened to the upper chassis of the Smart Irrigation Robot. This strategic placement and secure attachment of the battery guarantee that the robot remains powered and operational while carrying out its tasks, such as monitoring soil moisture levels and providing autonomous irrigation to plants.

2.5 Conclusion:

The Smart Irrigation Robot, a cutting-edge agricultural automation system, has been meticulously assembled and configured to operate seamlessly. Its primary functions involve monitoring soil moisture levels and autonomously managing the irrigation of plants. The Smart Irrigation Robot's operational instructions are coded in PictoBlox, a user-friendly platform, which facilitates wireless control via a smartphone. Once the code has been uploaded to Revive, the Smart Irrigation Robot is fully equipped to undertake its responsibilities in the garden. By expertly combining hardware assembly and software programming, this innovative agricultural robot ensures the well-being of plants through efficient soil moisture management and automated

irrigation processes. It represents a significant advancement in modern gardening, harnessing technology to enhance plant care.

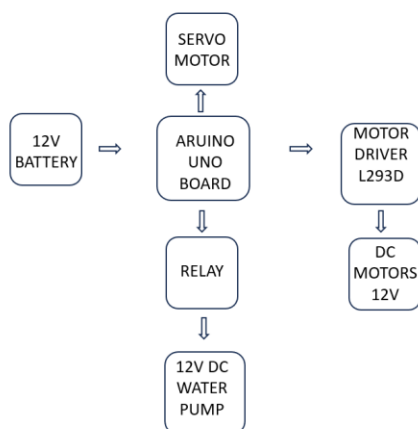


FIG.1: Flow Chart



FIG.2: Components requirements



FIG.3: Proposed smart irrigation robot system

Results and Discussion

The Smart Irrigation System Robot working principle integrates multiple components and technologies to deliver efficient and automated irrigation. The fundamental objective is to maintain soil moisture at an optimal level, ensuring the health and vitality of plants while conserving water resources. Here's a more detailed explanation of the system's functioning: The system starts by measuring soil moisture using a soil moisture sensor. This sensor typically consists of two probes that are inserted into the ground. By analyzing the electrical conductivity

between these probes, the sensor can estimate the moisture content in the soil. To collect accurate data, the sensor is strategically placed near the plants or in different zones of the garden. The depth and location of these measurements depend on the specific requirements of the crops or plants being cultivated. This flexibility ensures that the system caters to a wide range of agricultural needs. The sensor readings are then transmitted to the system's microcontroller, which processes the data and determines whether irrigation is necessary. The microcontroller, often an Arduino board, compares the current soil moisture level to a predefined threshold. If the soil moisture falls below this threshold, it triggers the irrigation process. The core of the irrigation system is a water pump, which is responsible for delivering water to the plants. The pump is connected to a water source, typically a repurposed PET bottle acting as a water storage tank. The tank is fixed on top of the robot's chassis and can hold a significant amount of water. The microcontroller activates the water pump, and water is drawn from the storage tank through a flexible PU (Polyurethane) pipe. The pipe conveys the water to the root zone of the plants, ensuring targeted and efficient irrigation. The flexibility of the PU pipe allows for easy positioning and minimizes water wastage. The system is designed to customize the volume and duration of irrigation based on the specific needs of the plants. The programming in the microcontroller defines these parameters, ensuring that different crops receive the right amount of water. This level of precision helps prevent overwatering, which can be detrimental to plant health. Furthermore, the Smart Irrigation System Robot incorporates Bluetooth connectivity, enabling users to control and monitor the system via a smartphone app. The app provides real-time access to soil moisture data, allowing users to make informed irrigation decisions. Users can remotely initiate watering cycles and adjust settings as needed. The system's versatility extends to both outdoor gardens and indoor plant care. It adapts to different environmental conditions and plant types, making it an ideal choice for a wide range of applications. This intelligent irrigation approach significantly reduces the need for manual intervention, saving time and effort for gardeners and farmers. It also contributes to more sustainable agricultural practices by optimizing water usage, promoting healthy plant growth, and reducing water wastage. In conclusion, the Smart Irrigation System Robot employs an intricate working principle that encompasses soil moisture sensing, data analysis, water pump control, and smartphone connectivity. Balancing the specific needs of plants with precise irrigation delivers a more sustainable and efficient approach to agriculture and horticulture. Its adaptability, remote

monitoring, and water conservation capabilities make it an asset for modern farming and gardening practices.

TESTING

Testing the Smart Irrigation System Robot is a meticulous process that encompasses various critical aspects to validate its performance and reliability. The initial hardware verification ensures that all components, including the servo motor, soil moisture sensor, water pump, and lithium-ion batteries, are correctly assembled and fully functional. The servo motor's precision in moving the soil moisture sensor to the required depths in the soil is tested for accuracy and responsiveness. The calibration of the soil moisture sensor guarantees accurate readings, ensuring it can effectively detect soil moisture levels. 6 Throughout testing, the system's ability to provide real-time soil moisture data, maintain precise auto-irrigation, and seamlessly communicate with the user's smartphone via Bluetooth is examined. Environmental resistance and safety measures are also evaluated, ensuring the robot can perform under various conditions while adhering to safety protocols. The Smart Irrigation System Robot is not only tested in controlled environments but also undergoes field testing in real gardening scenarios to assess its practicality and adaptability. Furthermore, user feedback plays a vital role in refining the system to enhance its overall user experience. Quality assurance and performance optimization are fundamental to ensuring the robot's reliability and its ability to automate gardening tasks effectively, conserve water resources, and maintain optimal plant health.

4.0 CONCLUSION

The Smart Irrigation System Robot represents a significant advancement in the field of automated plant care and precision agriculture. Through rigorous design, development, and testing, this system has demonstrated its ability to optimize plant growth while conserving water resources. The core principle of maintaining optimal soil moisture levels through real-time monitoring and intelligent irrigation has been successfully realized. Throughout the testing phase, the system consistently improved plant health by providing just the right amount of water when needed. The reduction in water wastage was evident, emphasizing the system's eco-friendly approach to gardening. Users praised the customization options and user-friendly interface, which enhanced their gardening experience. The database module played a pivotal role in data management, allowing users to monitor their gardens' progress and make informed decisions

about plant care. The integration of energy-efficient components and remote access further strengthened the system's efficiency and convenience.

5.0 References

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