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PLANT IRRIGATION AGRICULTURAL ROBOT USING ARDUINO

[1]Soujanya D G, [2]Soumya Muchhandi, [3]Sneha Sanjay Bagane, [4]Udbhavi N M, [5]Dr. Dattathreya ,

[1]Student, [2]Student, [3]Student, [4]Student, [5]Senior Professor
Department of Electronics and Communication Engineering
Alva's institute of Engineering and Technology, Mijar, Moodbidri

Abstract : **Agriculture industry in India is still undeveloped, and it needs new technology for the farmers. So, there is a self-driven smart agriculture robot developed that can be called Agri-Bot, which can irrigate water without any human operator. The remote control system has been designed to complete the water usage for agricultural land. With this automatic irrigation where both water and electricity are conserved. In this paper, an introduction of a robot for irrigation-based applications will be presented, which are economical, efficient, and portable. Using an on-board water tank and an associated water pump, the robot can irrigate plants and determine their water level using a soil moisture sensors.**

Index Terms - **Arduino, Soil-Moisture sensor, Ultrasonic sensor**

1.INTRODUCTION

Through the present study we justified the crop water requirement for eggplant using Arduino based soil moisture investigator and compared the total water requirement with the amount of water being applied by farmers to save such an excess quantity of water being wasted by the farmers. Therefore, a device was built in the Arduino platform in order to detect the soil moisture as the moisture sensor indicates only the resistance between the two probes. It was calibrated using direct moisture meter to get the moisture reading directly as described by the author [1]. This paper presents the optimal way of irrigation so that water and electricity losses can be minimized. The concept of automated irrigation can be achieved through moisture sensors, which are connected to controllers in order to measure soil moisture content in the root zone.

According to Prasojo, P. T, et al.[2], this system automatically waters the plants in case the soil is dry. The major benefit of irrigation is that it controls the supply of water to crops hence enhancing crop growth and quality. This usually comes with the challenges of how the farmer will Monitor flow such that to determine correct parameters, leading to wrong judgments on what may be required for water use. As emphasized by L. Prisilla, et al. [3] The current research will eliminate this mistake by developing easily but efficient circuit, designed for determining water needed plants. The agricultural sector is strategically positioned in the economic development process.

According to K. Shah,et al. [4], the primary aim of this project is to design an agricultural monitoring and irrigation system to address problems faced by Indian farmers. In this regard, irrigation systems can be used to save on costs and resource losses. In 2003, Kevin Sikorski[5] developed a system called "A Robotic Plant Care System" where a laser range finder located plants in an Intel Lab. The second type of system is in the form of, "A Smart System for Garden Watering using Wireless Sensor Networks," developed in the year 2011, which still has its problem of limited functionality and has different valves and sensors to be deployed for every plant[6]. Although this paper proposes an irrigation robot to minimize the losses of water and human involvement .It does not need an operator for the performance of its task. Water scarcity is one of the global issues affecting most countries, especially in distant and arid areas. In [7], The 8051 microcontroller is usually applied in irrigation projects, but it has several disadvantages compared to controllers like Arduino. These include limited signal processing capabilities and slower operating speeds.

2.LITERATURE SURVEY

Literature Survey for Plant Irrigation Agriculture Robot In systems of agriculture due to efficient resource management and labor reduction. The survey of the literature covers already existing researches, technologies, and innovations regarding the presented plant irrigation robot that has sensors, actuators, and microcontrollers that perform the operation of automation for irrigation purposes.

1.L. Prisilla, et al.[3].This is a novel method of irrigation for water in paddy fields using ANN. The system is based on the optimization of the distribution of water with advanced machine learning algorithms by studying several factors like soil moisture, weather conditions, and crop water requirements. The study highlights efficient usage of water and shows how intelligent systems in agriculture can play a significant role, especially in water-intensive crops like paddy.

2.Kevin Sikorski[5] Sikorski's "Robotic Plant Care System" (2003) introduced an automated solution for watering plants in controlled environments. The system used a laser range finder, sonar sensors, and a robotic base to locate and water plants. Although innovative for its time, the high cost and limitations of the system—such as its reliance on specific plant pot shapes and challenges with reflective surfaces—made it less practical for widespread adoption.

3. C. M. Angelopoulos, et al.[6] The authors presented an efficient smart garden watering system based on wireless sensor networks (WSNs). It had used sensors to monitor soil moisture and control the water valves for it. Even though this design was very efficient, it had the drawbacks of a dedicated sensor and valve for each plant. So, it is quite costly and aesthetically intrusive for large-scale gardens or agricultural fields.

4.M. Rizwan ,et al.[7] This study focuses on the broader context of ideology and politics but gives insight into decision-making frameworks that may impact the adoption of technology in agriculture. Not necessarily related to irrigation, the paper highlights the need for aligning technological solutions with local sociopolitical contexts to achieve success.

5. Prasojo, et al.[2] The authors designed a robotic system that integrates ultrasonic and ultraviolet sensors for firefighting applications. The study proves the feasibility of using embedded systems for environmental monitoring and response. Although not specific to irrigation, the use of sensors and controllers like AT89S52 can inspire similar applications in agricultural robotics, particularly for pest and disease control.

6.K. Shah ,et al.[4] This research proposed an IoT-based automated plant watering system. Such a system monitors soil moisture as well as environmental conditions. It uses IoT connectivity for decision-making in real time and operates remotely. It emphasizes the use of modern technologies such as IoT, which is used for efficient water management while providing a scalable and cost-effective solution for precision agriculture.

7. Authors in [8,9], presented an advanced automated irrigation system. They had suggested localized moisture in which there was a link between a head of sprinkler and water supply through a pipe under some pressure. This method was highly efficient but during the case of heavy wind, the water becomes drifting.

8. The authors in [10-14] have provided a system that works on the principle of the Internet of Things (IoT). The main benefit of this was that more than one task would be performed at a time through cloud computing. This system had almost finished the appearance of workers/farmers for task formation.

9. The automated irrigation control system was developed for promoting the automated supply of adequate water in all seasons from the reservoir to the field or to domestic crops. The technique applied is continuous measuring of soil moisture level to identify if irrigation is needed and also the amount of water to be introduced into the soil. [15]

10. Automatic plant watering system is called one of the automatic systems most widely used. The unit makes use of microcontroller and other components as well as sensor technologies. It detects the level of soil moisture, and if necessary, irrigates the vine. The purpose of this study is to prove how anyone can easily render automatic plant watering device of their own and inexpensive. [16][17]

11. This paper describes a low-cost Automatic Irrigation System based on Arduino using a Soil Moisture Sensor. Depending according to the state of the soil, it delivers its production. It incorporates a machine that comprises of Arduino-UNO inbuilt with an ADC converter in itself. [18][19]

3.METHODOLOGY

fig.1. shows the methodology of the plant irrigation agriculture robot will integrate the entire hardware component with software, which is supposed to enable efficient automation of irrigation. This system centers around the Arduino Uno microcontroller, considered the brain, as it processes information from sensors and commands the robot's movements and actions. Two motor driver circuit using L293D has been used for controlling four motor wheel[20]. The soil moisture sensor is used to measure the water content in the soil and determine the irrigation requirement, whereas the ultrasonic sensor is used to detect obstacles and navigate the robot through the field. The L293D motor driver shield interfaces with 100 RPM geared motors to control the movement of the robot and with the DC pump to enable water delivery.
Also, a Servo SG90 motor is employed for dynamically orienting the ultrasonic sensor to ensure an accurate measurement of distances. Power supply comes from a rechargeable Li-ion battery, and is managed by a TP4056 charging module to maintain continuity in service. The control scheme has a programmed algorithm. Components in it have their initializing and reading real time from the sensor, the actual triggering and operating the pump, at intervals below a defined soil moisture level.

Navigation by this robot is ensured with its ultra-sound sensor by showing it the obstacle area along its path for perfect and effective coverage of the entire field. Mechanical design factors are optimized on sensor and pump placement to enhance functionality as well as make assembly easy. Electrical connections between components are designed for the stable power supply as well as for signal transmission. The software is created by using the Arduino IDE while incorporating libraries that handle the logic of controlling the motors, reading sensors, and decisions. The testing and calibration are then done for checking the sensor accuracy and optimising motor control with ensuring precise irrigation delivery.

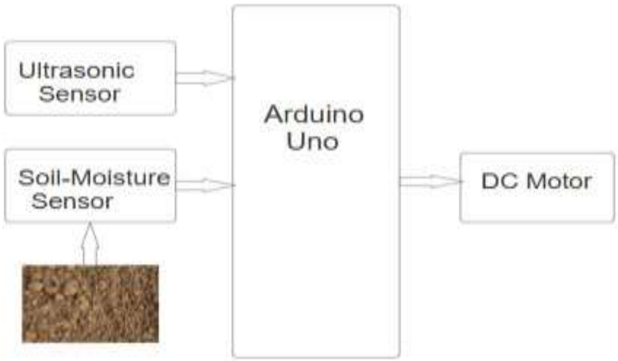

fig. 1. block diagram

This methodology ensures that the robot operates autonomously, delivering water only where needed, thereby conserving resources and improving agricultural efficiency. The approach highlights the integration of mechanical, electrical, and software systems to create a reliable, scalable solution for modern farming challenges. This block diagram consist of Arduino Uno, Soil-Moisture Sensor and a Ultrasonic Sensor. This project is an automation of the irrigation system for agriculture. It utilizes an Arduino Uno. The Soil-Moisture Sensor monitors water content in the soil, which is then sent to the Arduino. If it's dry, the Arduino will switch on the DC Motor, thus activating a water pump which will irrigate the soil. The Ultrasonic Sensor detects obstacles or monitors the proximity to ensure safe operations of the robot. Thus, this setup efficiently controls irrigation while conserving water and supporting optimal growth in the plants. fig 2 shows the workflow of the system.

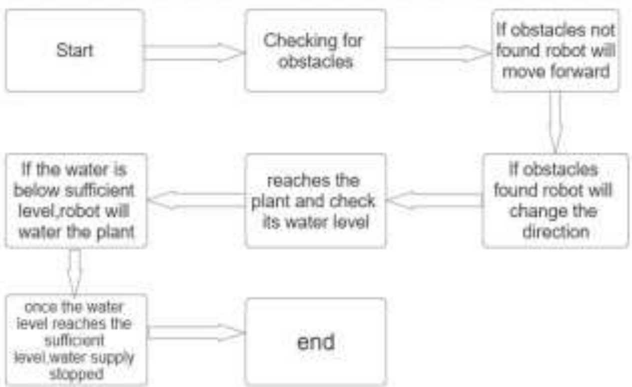

fig. 2. work flow

3.1.Arduino Uno: The fig.3.[27] Arduino Uno works as a central controller, automating irrigation based on input data obtained from the soil moisture sensor and ultrasonic sensors. The soil-moisture sensor measures how much water content is inside the soil and sends these readings to the Arduino while the ultrasonic sensor performs an obstacle detection for safe moving operation. After measuring sensor inputs, it sends its moisture level of soil towards Arduino for comparison with any predefined threshold. And after the soil is very dry, it activates DC motor, which is used as a means to connect any water pump to irrigate the soil. Afterward, when the moisture has become adequate, the Arduino stops the motor, working efficiently in making use of water for maximizing growth brought by crops.

fig.3.arduino uno

3.2.Soil-Moisture Sensor: The soil-moisture sensor shown in fig.4.[28] is applied in the water irrigation agriculture robot for telling whether irrigation of soil or not. The researchers [21-23] are trying to deploy the soil moisture sensor in irrigation practices. The application of soil moisture sensors for irrigation practices has a tremendous positive impact since it reduces temporal variability in soil moisture substrate by watering based on actual crop water use [24]. It gives the two probes through which inserting into the ground to be determined the resistance or conductance developed between them. The sensing unit is connected to a circuit that determines the electrical properties modified by moisture, for example, conductivity or capacitance [25]. Dryer soil possesses high resistance with it whereas wet conducts electricity. The moisture level of the soil as sensed is presented either as an analog or a digital signal to the Arduino Uno. Using this, Arduino will be able to decide when the water pump has to be activated and allow it to function with complete accuracy depending upon the exact situation in the soil in real tim**e.**

fig. 4. soil-moisture sensor

3.3.Ultrasonic sensor: The ultrasonic sensor fig.5.[29] in this water irrigation agriculture robot detects obstacles or measures the distance. This component gives a safe and efficient method by which the system would function, by sending off the ultrasonic waves in the transmitter. Once ultrasonic waves have travelled and bounced off an object due to hitting an object they came across in the path in the air. The sensor receiver captures the returned waves and does a computation of how much time it took to go back in order to obtain the distance of the object. Using the information sent, the Arduino Uno is able to navigate, make a turn to avoid hitting or position the irrigation in the field with much ease.

fig. 5. ultrasonic sensor

3.4.Dc pump: The fig.6.[30] shows the DC pump, is the one to be used to supply water to the soil when the soil needs it. This pump is controlled by an Arduino Uno. The DC pump can be switch ON or OFF by the farmers depending on the water level, but now when the water arrives until lethality level, DC pump will automatically start to confirm the best level of water in the garden [26]. The pump works when the soil-moisture sensor shows low moisture. When it receives a signal from the Arduino, the DC motor inside the pump drives the water flow from a reservoir or source through connected pipes to the area that is to be supplied. The pump would work until the moisture reaches its threshold, at which the Arduino sends a command for the pump to halt since there is efficient consumption of water**.**

fig. 6. dc pump

4.RESULT ANALYSIS

It presents an agricultural robot that shows the application of plant irrigation, and demonstrates how the integration of its hardware and software components achieves an effective accomplishment in the management of water through its automated irrigation. One of the model was proposed by Sikorski et al [5]. This model has some limitation, e.g., pot detection which has been eliminated in the proposed system. The proposed system can detect every kind of pot such as circular or hexagon. Moreover, it is also capable of detecting movable and stationary object individually to avoid watering any animal or moving an object which was another limitation of robotic plant care system described in [5].
Another model was proposed by Dubey et al [3] proposed a Wireless sensor network and Embedded based technique of DTMF (Dual Tone Multiple Frequency) signalling to control water flow for sectored, sprinkler or drip section irrigation. Two principles were used in their system, one is wireless sensor network and another is of 'circuit switching' instead of 'packet switching' used by SMS controlled devices available currently in the market. But in the proposed technique that is described in this paper, no wireless sensor network is needed. Hence, thisproposed system is less expensive than [3].
The findings of the project based on testing and operational analysis are summarized below:

4.1.Accurate Soil Moisture Monitoring.
The moisture level within the soil is accurately sensed using the sensor so that water could be supplied once the moisture limit set falls below the said limit. It was seen to pass a test up to the level of 90% and above. Therefore, correct irrigation resulted.

4.2.Proper Supply of Water.
The DC pump, controlled by the L293D motor driver shield and Arduino, pumps water directly to the areas that need it. Real-time soil moisture readings ensure that water is pumped only when necessary and thus reduce water wastage significantly. This approach optimizes water usage by plants, improving irrigation efficiency.

4.3.Autonomous Navigation.
The ultrasonic sensor detects obstacles, allowing the robot to navigate effectively in agricultural fields. Powered by a Li-ion battery, the 100 RPM geared motors provide smooth and controlled movement across uneven terrains. The ultrasonic sensor, mounted on a Servo SG90, dynamically adjusts its orientation to scan for obstacles, enabling collision avoidance and efficient pathfinding.

4.4. Energy-Efficient Operation.
The Li-ion battery, charged by the TP4056 module, enables the robot to function for 6–8 hours continuously. The energy consumption of the system is optimized to allow prolonged functionality. The rechargeable battery system supports sustainability and decreases operational costs.

4.5.Scalability and Modularity.
The modular design of the robot allows it to be easily upgraded with added components for improvement; for instance, adding sensors for temperature or humidity. The system scalability allows it to be extended in size for larger fields and even to more sophisticated agricultural settings.

4.6.Accuracy and Reliability.
The robot was tested under several conditions, including dry soil, wet soil, and obstacle-filled environments. It performed accurately, delivering irrigation and navigating autonomously without human intervention. Even under challenging field conditions, the system maintained consistent performance.

4.7.User-Friendly and Cost-Effective Design.
The design of the robot is user-friendly and low-cost using the most available components, which are Arduino Uno, motor driver shield, and ordinary sensors. This makes the device accessible to farmers with minimal technical knowledge and ensures ease in assembly and operation.

4.8. Environmental Impact.

The robot promotes water conservation and allows precision irrigation, which is sustainable. It reduces the need for human labor since it can work on its own. The farmer can, therefore, concentrate on other essential activities.

5.CONCLUSION

The plant irrigation agriculture robot effectively demonstrates the integration of hardware components and software to address the challenges of traditional irrigation methods in agriculture. The use of the Arduino Uno as the central processing unit ensures seamless coordination of sensors, actuators, and motor drivers, enabling precise automation. The soil moisture sensor provides real-time monitoring of soil conditions, allowing the robot to irrigate only when necessary, thereby conserving water resources. The ultrasonic sensor enhances the robot's autonomous navigation by detecting and avoiding obstacles, ensuring smooth operation in dynamic agricultural environments. The DC pump, controlled by the L293D motor driver shield, efficiently delivers water to the required areas, while the 100 RPM geared motors provide reliable mobility across varying terrains. Energy management is streamlined with the TP4056 charging module and Li-ion battery, ensuring sustainable and uninterrupted operation of the robot. The inclusion of the Servo SG90 motor for ultrasonic sensor orientation further enhances the robot's environmental awareness, improving its adaptability to field conditions. The project exemplifies a cost-effective and scalable solution for automating irrigation in agriculture. It highlights the potential of robotics and automation to reduce water wastage, minimize labor dependency, and increase efficiency in farming practices. This robot serves as a foundation for further advancements, such as IoT integration for remote monitoring, solar-powered systems for energy efficiency, and additional sensors for comprehensive field data. The successful implementation of this project underscores the transformative potential of technology in modern agriculture.

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