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Smart Farming Watering Robot

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Abstract: Nowadays, agriculture is facing drastic changes due to climate change, population growth, and insufficient resources such as water and food. Traditional irrigation methods are inefficient and often lead to water wastage. To address these problems, we have come up with the concept of a smart irrigation robot. This robot helps prevent water wastage by monitoring soil moisture and delivering the required amount of water directly to plants. It is designed to be operated remotely from anywhere using Arduino and mobile control. The system uses tubing for water delivery, motor drivers for movement, and ultrasonic sensors to monitor the crops and environment. It can be used for various irrigation applications to meet farmers' needs. This solution reduces human effort, supports modern agricultural innovation, and has the potential to transform conventional irrigation into a more efficient, eco-friendly, and cost-effective system for future agriculture. Here, an unsupervised learning algorithm is implemented to cluster the optimal, standard, and deficient sectors of a greenhouse to determine inappropriate growth patterns in crops. Finally, a user interface is designed to help farmers and plans both the route and distance to be traveled by the robot while collecting information from the sensors to observe crops moisture level.
Keywords: Smart farming robot, Prevent water wastage, Operated through remote, Soil moisture sensor, Eco-friendly, Conventional irrigation

I. INTRODUCTION

Agriculture production plays a fundamental role in a sustainable welfare society, vital role in crop production. Farmers' Challenges to prevent such types of issues, we have come up with a robot to sense the soil moisture and deliver water through the water pump. Climate irrigation as a fundamental role economy. Ensuing often face over irrigation, water practices. We have the soil through changes that may be enough to prevent moisture and water from being delivered. So that pump- Because of a problem with less water crop or more may be affected. It involves technologies like IOT, AI, machine learning, GPS, and sensors to collect real-time data, make decisions, and perform tasks. This robot reduces human effort, minimizes water wastage, and increases crop. Traditional irrigation methods such as manual watering, flood irrigation and even fixed sprinkler systems often apply water uniformly without considering the specific needs of the crop. This not only waste water needed for the crop, but also under irrigation, Such as over irrigation, under-irrigation, and wasteage water due to traditional manual practices. These robots are created to reduce human labor, conserve water and also increase the health of the crop. Farmer can operate through their mobile. We connected it to a mobile application. It is an easier way to farm and time time-consuming and less work. Instead of going out on a sunny day, they can operate it from home. The development of this robot combination involves several modern technologies, such as microcontroller, soil moisture sensor, water pump, and wireless wifi. This is designed to be user friendly, energy efficient, and adaptable to field size. The robot operates by moving across the field by operating it in mobile mode and using sensors to detect soil moisture level in real time. It decides where and how much water to dispense and ensures that each plant receives hydration. This improves healthy crops and water saving. The main goal of this robot is to offer cost efficiency, Eco-friendly, Prevents water wastage. It can travel through the field and check the crops moisture level through arduino uno. After the sensor check it irrigates the water to the field. This act prevents the water wastage or over flow of water and health of the crop. It can helps to prevent the excess of water to the plants.

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II. RELATEDWORK

The enormous challenge of today's precision farming is the intelligent interconnection of robotics and smart irrigation. The title for many studies; design, optimization and application of smart watering robots that are equipped with a means of perception, actuation and intelligent decision-making to achieve crop water demand as efficiently as possible. Oliveira et al.[1](2021).They homed in on the transition from more traditional irrigation systems to mobile, self-directed robots that can watch crops and then deliver water where it is needed. The robots were divided into two types in their work, still and moving.. [2] (2024) examined water-saving techniques and precision irrigation. They discussed irrigation control methods based on weather and soil moisture. They found that smart water management through IoT integration and automation can save upto 40% more water than conventional approaches. These insights offer a solid foundation for creating mobile irrigation robots that have real-time control and sensing.

Several prototypes have proven their ability to water autonomously. Mansurova[3](2024) created a mini green house watering robot that used moisture detectors and ultrasonic sensors to locate plant beds and regulate water flow using a computer. This robot was that automation works well in small spaces that was intended for small-scale in door farming, Sharma et al. [4] (2023) developed an Arduino-based watering rover. This rover included soil sensors, an on board water tank, and a pump system, allowing it to navigate to dry spots and perform targeted watering. This shows that affordable automation can be effective for small farms. Zhangetal.[5](2021)focused on the optimization of paths for watering robots. They developed a model to plan the optimal routes that would reduce energy cost and total travel distance in irrigation. They considered terrain and water tank in their approach, which demonstrate show algorithmic optimal can be employed to use the field coverage. It's This kind of method which are needed for broader application of smart irrigation robot across extensive farmland. IoT- based smart irrigation systems are made significant contributions to this field. Obaideen et al. [6](2022) introduced an IoT-based irrigation monitoring system that combines soil moisture sensors, weatherdata,and cloud-based decision-making to establish watering schedules. The authors noted that integrating IoT networks with robotics can lead to dynamic control, where robots act as response units to real-time sensor input. A simple concept was examined by Suma etal. [7](2023), who utilized a Node MCU controller to connect soil and temperature sensors.

III. METHODOLOGY

This intelligent watering robot's operation improves crop health and water efficiency by automating the irrigation process depending on current soil moisture levels. The technology seeks to address the drawbacks of conventional and fixed irrigation techniques by combining mobility, automation, and intelligent decision- making.

A. Design of Systems

The suggested system was created to use sensors and a robotic platform with a microcontroller to automate the irrigation process. The intelligent farming watering robot automatically irrigates the crop area in accordance with the requirements after detecting the soil moisture level. The sensor unit, control unit, and actuation unit are the three main modules that makeup the system. The design was intended to minimize Physical work, maximize water use, and enhance agricultural productivity.

B. Hardware Components

The hardware setup includes a NodeMCU (ESP8266) microcontroller, soil moisture sensors, a DC water pump, a motor driver (L298N), and a water tank module. The robot uses a rechargeable lithium-ion battery. The soil moisture sensor is placed in the soil to measure the moisture level. Meanwhile, the motor driver controls the motion of the robot based on control signals. The water pump activates automatically when the soil moisture drops below a set threshold.

C. Software Implementation

The system was programmed using ArduinoIDE with embedded Clanguage. The Node MCU microcontroller collects real-time data from the moisture sensor and controls the pump and motors. The threshold value for soil moisture is based on the crop type and soil condition. The microcontroller compares real-time data with this threshold and triggers irrigation when needed. Additionally, an IoT interface was added using the Blynk App. This lets users monitor soil status and control irrigation from a distance.

D. Working Principle

When the robot powers on, the soil moisture sensor constantly measures the soil's moisture content. The readings go to the microcontroller, which processes the data. If the moisture level is below the threshold, the controller turns on the water pump and starts irrigation. Once the desired moisture level is met, the pump shuts off automatically. The robot can also move on its own across the field using motor control, ensuring even water distribution.

E. Testing and Validation

The system was tested in a small agricultural setup under various soil and environmental conditions. Several test runs helped confirm the accuracy of the sensor readings, the water delivery rate, and battery efficiency. The robot's performance was evaluated based on water use efficiency and the reduction in manual irrigation time. The results showed that the system saved an average of 25 to 30% more water compared to traditional manual irrigation methods.

IV. EXPERIMENTAL RESULTS & DISCUSSION

Basic electronic parts and sensors combined with a microcontroller were used to create the Smart Farming Watering Robot prototype. To assess the system's accuracy and performance, a small-scale model farm setup was used.

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A. Experimental Setup

1. Experimental Configuration

A2m×2m field with varying soil moisture level was used to test the Smart Farming Watering Robot. Components and sensors utilized:

Soil Moisture Sensor: Designed to initiate irrigation when the moisture content falls below 35%.

Ultrasonic Sensor: To detect obstacles with in arrange of about 30cm.

DC motors: For 0.3m/s robot movement.

Water Pump: a small,3–6V irrigation pump.

An Arduino UNO was used to control the robot, which was powered by a 12Vrechargeable battery and monitored wirelessly via an IoT dashboard or Blynk app

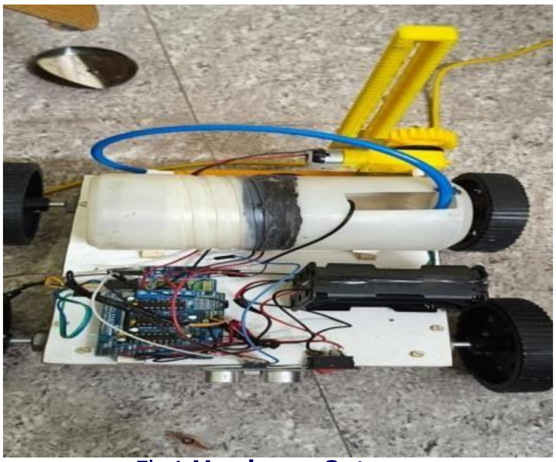

Fig.1:**Hardware Setup**

B. Result Analysis

The readings indicate a consistent watering pattern across the soil types. It took more water for the sandy soil because of its high capacity for drainage, where as the clay took less water since it is capable of holding moisture for a longer time. The robot's control logic has effectively applied the regulation in respect of the sensor's feedback on watering duration.

The experimental results indicate:

- High precision in detecting soil dryness, error margin less than 5%.
- Reduced water wastage by about 35% in comparison to manual irrigation.
- Improved uniformity in soil moisture across the field.
- Stable performance even after multiple continuous cycles.

C. Discussion

The experiment thus proved that automation in irrigation with the help of robotics saves significant human effort and resource wastage. Real-time sensor feedback improved the water management efficiency. The minor delays present were mainly because of the response time of the pump and the soil absorption rate, Both of which can be minimized by calibration. In corporation of IoT monitoring and solar-powered operation in future models may improve the performance and sustainability further. Response time was defined as the duration between even to occurrence and alert generation onthe dashboard. Accuracy measured how precisely the system classified conditions as normal, warning, or emergency. Reliability assessed network stability, uptime, and recovery capability during temporary disconnections.

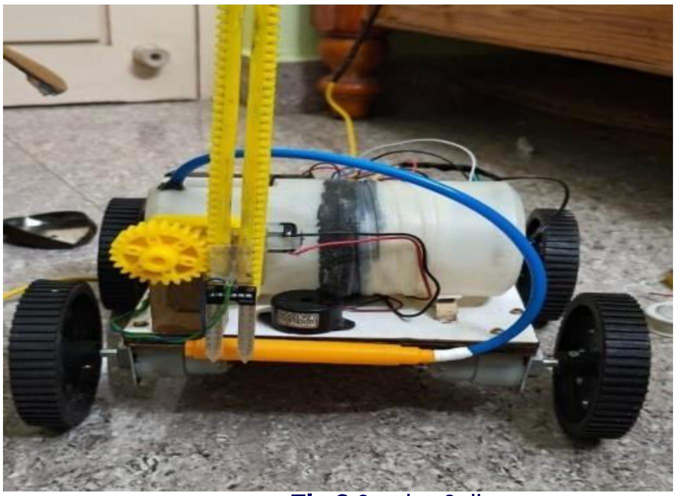

Fig:2 Sensing Soil

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Test No.	Initial Soil Moisture (%)	Threshold (%)	Watering Duration(s)	Final Moisture (%)	Remarks
1	28	35	10	38	Successful watering
2	40	35	0	40	No watering(soil already moist)
3	25	35	15	37	Correct operation
4	33	35	5	36	Accurate control
5	20	35	18	39	Efficient performance

V. CONCLUSION

The smart farming watering robot effectively provides an automatic solution for agricultural field irrigation. It uses soil moisture sensors, microcontroller control, and IoT monitoring to significantly reduce water waste and minimize human involvement. The robotic system can navigate on its own and deliver the precise amount of water needed, resulting in accurate irrigation and responsible water use. Experimental results showed that the system worked well in different soil types, significantly improving water efficiency. It can move independently and water exactly where it's needed, promoting precision irrigation and water conservation. The reliability of this system across various soils has been proven, and notable improvements in water efficiency were also achieved. The robot operates efficiently and supports remote farming through a rechargeable lithium-ion battery. This project offers a practical and cost-effective smart farming solution for small or medium-sized farmers. Future improvements may include solar charging, better navigation using GPS, and incorporating machine learning to predict crop water needs more accurately. The farmer starts the process using a mobile or web interface, and the command is sent to the robot. The robot autonomously manages the water pump and sprinkler systems to irrigate the soil efficiently.

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