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Soil Moisture Monitoring Robot

Arjun Pachpor[1], Darshan Raut[2], Sanket Pandhare[3],
Apeksha Sarode[4], Khushi Meshram[5], Sakshi Palaskar[6]
Electrical Department[1-6]
Shri Sant Gajanan Maharaj College of Engineering, Shegaon, India

Abstract: *This paper proposes an autonomous Soil Moisture Monitoring Robot for precision agriculture. The system has a dual controller for efficient wireless communication and remote data transmission. Another controller is used for processing soil moisture data collected by sensors.*
An all-wheel drive (AWD) system is used for efficient movement on irregular agricultural surfaces. The robot can run in autonomous mode or remote mode for real-time soil moisture data collection for further analysis.
The proposed system is efficient for water management, saves manual effort, and is useful for data-driven decision-making in precision agriculture, thus promoting increased crop production..

Keywords: Autonomous Robot, Embedded System, ESP8266, IoT, Precision Irrigation, Real-Time Monitoring, Smart Agriculture, Soil Moisture Monitoring, Sustainable Farming, Wireless Sensor Network

I. INTRODUCTION

In recent times, agriculture has experienced tremendous changes with the incorporation of modern technologies with the aim of improving efficiency and sustainability. One of the most important issues in modern agriculture is the management of water resources, as improper irrigation may cause wastage of water resources, resulting in soil degradation and reduction of crop yield. It is important to monitor the soil moisture level to determine the optimal irrigation needs of the crops, especially with the changes in climatic conditions.

This project proposes a Soil Moisture Monitoring Robot with the aim of providing an automated solution to monitor the soil moisture level. The proposed system incorporates IoT-based technology to monitor the soil moisture level by incorporating sensors and microcontrollers to communicate with a server or mobile devices.

The proposed system has several features, including its ability to move autonomously through an all-wheel drive system. This allows it to traverse different types of agricultural terrain, including uneven and soft soil surfaces. This way, it is possible to obtain comprehensive information from different areas of the field. Furthermore, the proposed system has dependable sensor systems for obtaining accurate and updated soil moisture levels.

The proposed system has several benefits, including minimizing manual work and optimizing irrigation practices. This way, it is possible to promote water conservation and sustainable agriculture. In addition, crop productivity is maximized through this system. This proposed system is particularly beneficial for regions experiencing water scarcity. This is because it allows for proper management of water resources and promotes water conservation.

II. LITERATURE REVIEW

Soil moisture is one of the key factors in the field of agriculture as it affects the development of the crop and the yield directly. Therefore, monitoring the moisture level of the soil is essential to avoid the wastage of water resources and to promote the development of sustainable farming techniques. However, the conventional techniques employed to monitor the level of moisture in the soil are considered to be inefficient and are still in the manual mode of operation. As technology is improving every day, automated techniques of monitoring the moisture level of the soil using the integration of sensors and wireless technology have also started to take shape.

In the recent past, the integration of robotics technology with the system of monitoring the level of moisture in the soil has improved the efficiency of the system significantly. The mobile system of monitoring the level of moisture in the soil can collect real-time data from the different locations of the agricultural field, which can provide accurate data regarding the moisture level in the soil. The system is also equipped with the facility of all-wheel drives, which can operate on different types of surfaces, including uneven and rough surfaces.

Microcontrollers are used in these systems, which play a crucial role in their operation. Microcontrollers are used for data acquisition, processing, and communication in these systems. In this system, Arduino microcontrollers are used for data acquisition and processing, while ESP8266 modules are used for data communication and transmission. This is because Arduino microcontrollers are used for data acquisition and processing in soil moisture sensors, while ESP8266 modules are used for data communication and transmission in these systems. The inclusion of Wi-Fi technology in these systems enables data transmission to cloud servers or mobile devices, which enables farmers to make effective decisions regarding irrigation activities in their farms.

In addition, the inclusion of autonomous movement and data transmission in these systems enhances their efficiency in operation. This is because the robot can move on its own in the field, enabling it to acquire data without any human intervention. This enables farmers to make effective decisions regarding the soil moisture levels in their farms, thus promoting sustainable agriculture. This is because these systems help farmers in conserving water, reducing the cost of operation, and promoting effective decision-making in the field.

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III. METHODOLOGY

The microcontrollers are also very vital in the soil moisture monitoring system as they assist in the acquisition, processing, and communication of the data. The Arduino microcontrollers assist in the acquisition and processing of the data from the soil sensors, ensuring accurate measurement of soil conditions so that farmers can make proper irrigation decisions.

The incorporation of the autonomous movement also assists in the efficiency of the soil monitoring system. The robot has the ability to move independently in the agricultural field, ensuring that it collects the data from the soil in various locations without the assistance of humans. Therefore, the soil monitoring system assists in the optimization of the water usage, ensuring that the agricultural activities are carried out in an efficient way.

BLOCK DIAGRAM

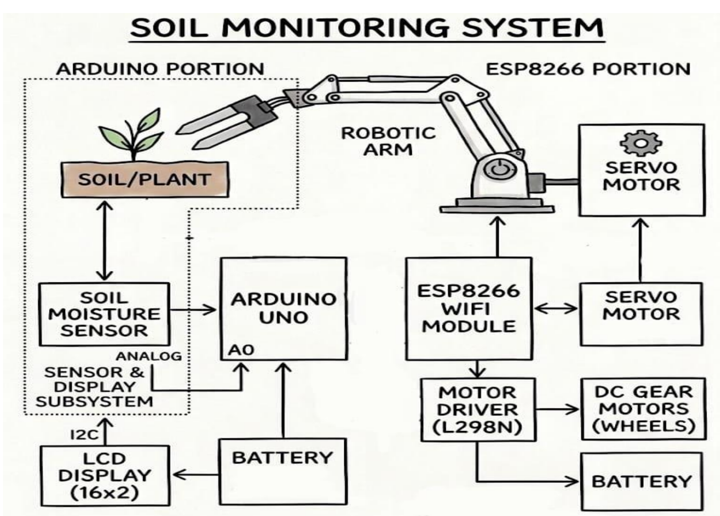

Fig. 1: Block Diagram of the Soil Monitoring System

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1. Power Supply (Battery Unit)

The battery acts as the main power source for the entire system. The battery provides power to all the main components of the system, including the microcontroller, motor driver, and sensor units, as well as the display unit. A power supply is necessary to provide power to the system to ensure efficient and continuous operation of the robot in the field environment.

2. Control Unit (Microcontroller System)

This unit of the system acts as the brain of the system and consists of a microcontroller, typically an Arduino board. The microcontroller receives data from the sensor units and performs the following operations:

- Processing of data received from the soil moisture sensor units
- Regulation of the motors using the motor driver unit
- Transmission of data to the display unit
- Overall system coordination and management
- In some cases, as mentioned in your report, a dual microcontroller system may be employed to enhance the efficiency of the system in terms of data communication and sensor operations.

3. Soil Moisture Sensing Unit

This unit consists of soil moisture sensor units in direct contact with the soil. The main function of this unit is to:

- Determine the volumetric water content in the soil
- Convert the received data into an electrical signal
- Transmit the data to the microcontroller unit in real time
- This allows efficient monitoring of the soil environment, which is necessary to make efficient irrigation decisions.

4. Motor Driver (L298N)

The motor driver, L298N, connects the microcontroller and DC motors. Since the microcontroller cannot provide enough current to power the motors, it:

- Amplifies the signals
- Controls the motors' direction
- Regulates the speed of motors

5. DC Gear Motors (Mobility System)

The DC gear motors attached to the wheels provide the robot's mobility. These motors, connected to the motor driver, provide the robot's ability to:

- Move forward and backwards
- Turn and move around
- Operate on different terrains in agricultural fields
- This helps the robot's all-wheel drive mechanism move around the field efficiently.

6. Display Subsystem (LCD with I2C Interface)

This subsystem consists of an LCD module connected to the microcontroller using I2C communication protocol. The main functions of this subsystem include:

- Showing the real-time soil moisture values
- Showing the status of the system
- Providing a user-friendly interface to monitor the system
- I2C communication protocol simplifies the wiring and communication process between the microcontroller and LCD module.

7. Interconnection and Data Flow

This system's data flow and interconnection process occur in the following order:

- Soil moisture sensors receive data from the field

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- Microcontroller receives data from the sensor
- Data displayed on the LCD screen
- According to the microcontroller's logic, it sends a signal to the motor driver
- Motor driver receives the signal and drives the DC motors to move the robot
- Battery powers all the subsystems in the robot.

IV. WORKING

The principle behind the operation of the soil moisture monitoring robot involves the integration of sensors, microcontrollers, and wireless communication technologies, as well as the autonomous movement of the robot. The operation of the soil moisture monitoring robot involves the continuous measurement of the soil moisture levels in various locations in the field, as well as the communication of the measured soil moisture levels in real-time.

The soil moisture sensor is inserted into the soil, and the soil moisture level is measured based on the electrical properties of the soil, such as resistance or capacitance. The measured soil moisture level generates an analog signal, which is sent to the Arduino microcontroller, and the measured soil moisture level is converted into meaningful values by the Arduino microcontroller.

At the same time, the movement of the robot is achieved by using the motor driver (L298N), which is connected to the BO motors and the wheels of the robot. The motor driver receives the signal from the Arduino and moves the motors accordingly, enabling the robot to move across the field. The all-wheel drive system helps the robot move over different types of surfaces, such as uneven or rough surfaces or muddy surfaces.

As the robot moves, the collection of the data regarding the moisture level of the soil from various points is continuous, which increases the accuracy of the monitoring system. The data is also displayed on the LCD display device fitted on the robot. LED indicators are also used to display the status of the soil, i.e., dry or wet.

It can be concluded that the robot operates independently or with minimum human input and can effectively collect the data regarding the moisture level of the soil and then transmit the same in the best possible way. This monitoring system can be used to optimize the usage of water resources and promote the concept of sustainable farming.

V. EXPERIMENTAL SETUP & RESULT

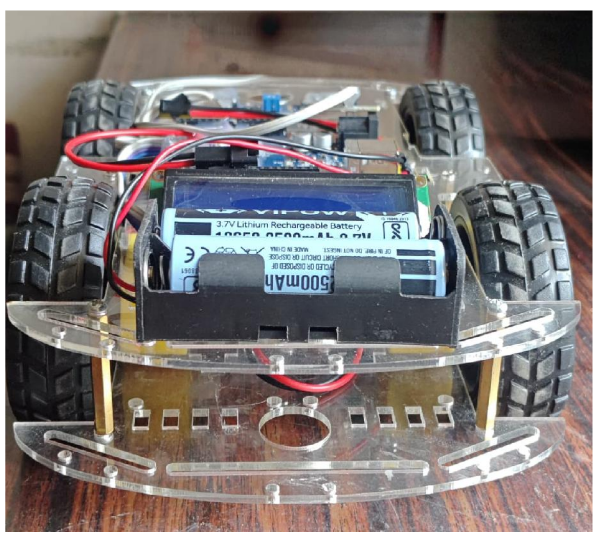

Fig. 2: Hardware module of Soil Moisture Monitoring Robot

The designed soil moisture monitoring robot was tested under various soil conditions to check its efficiency. The soil moisture monitoring system was able to accurately sense the soil moisture levels and display them on the LCD screen.

The combination of Arduino and ESP8266 was helpful in acquiring, processing, and transmitting the data without much delay.

The soil moisture monitoring robot showed great mobility on various surfaces, such as dry soil and slightly uneven surfaces, due to its all-wheel drive mechanism. The robot was able to obtain data from various points in the field, thereby enhancing the reliability of the soil moisture monitoring system.

From the results, it is clear that the proposed system is reliable, cost-effective, and efficient for implementing smart agriculture practices. It minimizes manual effort, optimizes water usage, and promotes sustainable agricultural practices.

VI. CONCLUSION

The Soil Moisture Monitoring Robot is an innovative and efficient solution that represents the future of modern agricultural management, utilizing automation, sensing, and communication technologies. The robot has the ability to operate on different types of terrain, including uneven and rough terrain, due to its robust all-wheel-drive capability, thereby efficiently monitoring the soil conditions of different types of agricultural land.

The project employs advanced soil moisture sensing technology, allowing the system to continuously monitor the soil conditions and provide the farmer with the correct information regarding the soil moisture level at any given time. The efficiency of the Soil Moisture Monitoring Robot is the most important aspect of this project, as it has the ability to operate efficiently, thereby making the most efficient contribution towards the development of precision agriculture.

Environmental conditions, the operating range of the robot, and the availability of power may act as some of the challenges affecting the efficiency of the Soil Moisture Monitoring Robot, even though the efficiency of the robot is the most important aspect of this project, allowing it to make the most efficient contribution towards the development of precision agriculture.

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