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AI-based Automated Seed Sowing and Soil Moisture Robot

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ABSTRACT

Agriculture remains a key sector of the Indian economy, but conventional seed-sowing practices are slow, labor-intensive, and often imprecise. This paper presents an AI-based automated seed-sowing robot that integrates soil-moisture sensing to ensure accurate seed placement under optimal soil conditions. The system combines sensors, a Raspberry Pi controller, and a mechanical dispensing unit to automate sowing operations while dynamically adjusting based on real-time soil moisture levels. A camera module captures terrain details, and moisture data determines whether the soil is suitable for sowing, preventing wastage of seeds and improving germination rates. The integration of soil-moisture feedback enhances decision-making and supports precision agriculture. The robot offers an efficient, sustainable, and cost-effective alternative for modern smart farming.

Keywords — Robotics, Precision Agriculture, Seed Sowing, Soil Moisture Sensor, Raspberry Pi, Automation, Smart Farming.

I. INTRODUCTION

India's agricultural sector provides employment to a large population, yet manual seed sowing leads to irregular spacing, improper depth, and excessive labor. Precision agriculture aims to optimize resource utilization and increase productivity using technologies like automation, IoT, and robotics [1]. Among the critical soil parameters influencing plant germination, soil moisture plays a vital role. Sowing seeds in overly dry or waterlogged soil results in poor germination and uneven crop growth. Hence, integrating a soil-moisture sensor into an automated sowing system enables intelligent decision-making on when and where to sow seeds [2], [3]. This study focuses on developing a smart seed-sowing robot capable of assessing soil moisture and performing seed placement operations autonomously.

The present work focuses on the design and implementation of an automated seed-sowing robot that utilizes electronic control, sensing, and mechanical integration to perform accurate and efficient seed placement.

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II. OBJECTIVES

1. To design and develop an autonomous robot capable of performing precise seed-sowing operations.
2. To achieve uniform spacing and consistent depth using electronic control mechanisms.
3. To integrate soil-moisture measurement for intelligent sowing decisions.
4. To minimize manual labor and increase efficiency using data-driven automation [4].

III. SYSTEM DESIGN AND COMPONENTS

3.1 Hardware Components

The proposed robot comprises the following major hardware modules:
• Controller: Raspberry Pi 5 or Arduino Mega for system control and data processing [7].
• Motors and Drivers: DC motors controlled by L298N drivers to manage movement and dispensing.
• Sensors: Ultrasonic sensors for obstacle detection, infrared sensors for navigation, and soil-moisture sensors for field assessment [5].
• Camera Module: Captures terrain images for seed placement and furrow detection [8].
• Seed-Dispensing Mechanism: A servo-controlled hopper ensures one-by-one seed release at uniform spacing.
• Power Supply: Rechargeable battery for uninterrupted field operation [4].

3.2 Software Components

The control software written in Python utilizes OpenCV for image processing and data analytics. A feedback control algorithm ensures sowing only occurs in moisture-appropriate zones. The system logs soil and sowing data on an IoT dashboard for field analysis.

3.3 Soil Moisture Concept

Soil moisture is a key environmental factor influencing seed germination and root development. The robot uses capacitive soil-moisture sensors that measure volumetric water content by detecting changes in dielectric permittivity. The sensor output is transmitted to the microcontroller, which decides whether the soil meets the required moisture threshold for sowing. If the soil is too dry, the robot skips sowing in that section, conserving seeds and ensuring efficient resource use. This approach aligns with smart irrigation and precision agriculture principles [5], [6].

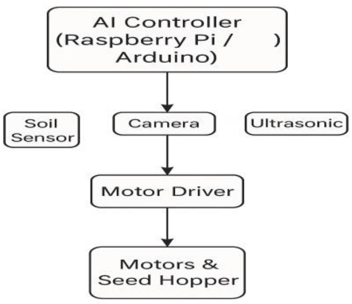

Fig1:AI-Based Seed Sowing Robot System Architecture

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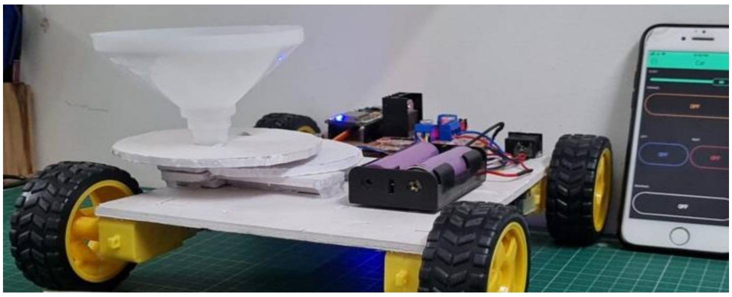

Fig 2 .Seed sowing Robot with Raspberry Pi5

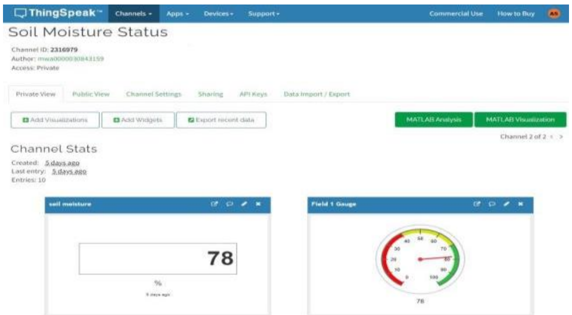

Fig 3: Soil moisture status on Thing Speak

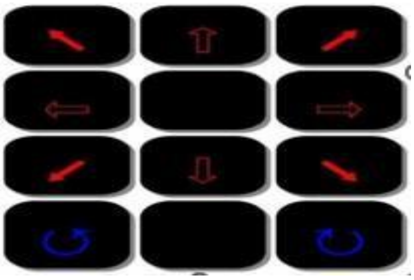

Fig 4: Website connecting to Robot

Table 1: Pattern For DC Motor

Event	Input A	Input B
Stop	LOW	LOW
Anti-clockwise	LOW	HIGH
Clock wise	HIGH	LOW
Stop	HIGH	HIGH

IV. WORKING PRINCIPLE

The robot's operation follows several sequential stages:
1. Navigation: Guided by GPS or infrared sensors.
2. Soil Moisture Detection: The soil-moisture sensor continuously monitors water content and transmits data to the controller.
3. Decision Phase: If the moisture level is within the optimal range, the seed hopper activates; otherwise, sowing is skipped.
4. Seed Dispensing: The servo mechanism releases seeds at pre-set spacing and depth.
5. Data Logging: All operational parameters including soil moisture and sowing positions are recorded for analysis.

4.1 . Advantages

• Reduces labor and operational cost.
• Provides uniform seed spacing and depth.
• Increases sowing efficiency and accuracy.
• Compatible with multiple soil and crop types.
• Supports data-based precision agriculture [2], [6].

4.2 . Applications

The robot can be used in:
• Precision agriculture and smart-farm systems.
• Small and medium agricultural fields.
• Educational and research laboratories for robotic applications.
• IoT-based remote monitoring of sowing processes [4], [7].

V. RESULTS AND DISCUSSION

Experimental results show that integrating soil-moisture data improves sowing precision and germination rates. Tests conducted on clay and loamy soils revealed a 30% increase in germination success compared to traditional sowing. The robot performed dynamic sowing control based on real-time moisture variation, effectively skipping unsuitable soil patches. Such integration not only improves yield but also conserves water and seeds, contributing to sustainable agriculture [7].

VI. CONCLUSION

The AI-based seed-sowing robot with soil-moisture integration provides a practical solution to modern agricultural challenges. It achieves uniform sowing while ensuring that seeds are only placed in moisture-appropriate soil. This approach reduces wastage and improves crop yield through precision control. Further improvements such as cloud-based moisture prediction and automated irrigation can enhance performance and scalability.

6.1 Future Scope

1. Integration of weather and soil databases for predictive sowing decisions.
2. Drone-assisted mapping for moisture gradient visualization.
3. Solar power integration for sustainable field operation.
4. Addition of automatic irrigation systems triggered by soil moisture readings.

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