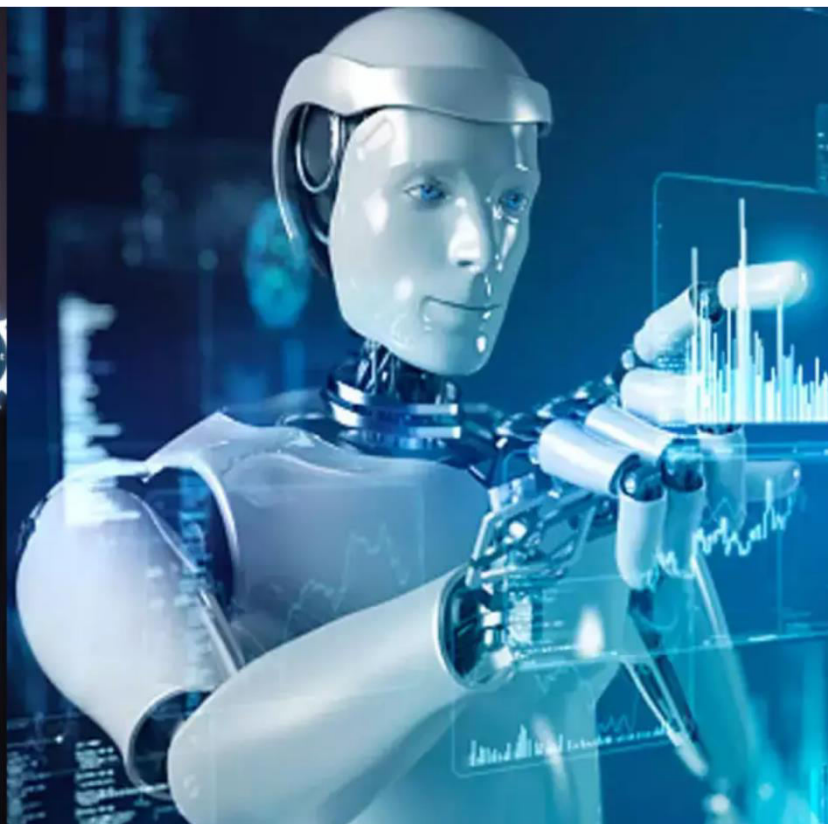




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Agribot for Seed Plantation

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ABSTRACT: Traditional seed planting methods are often labor-intensive and prone to errors, leading to lower yields and increased environmental impact. Recent advancements in agricultural robotics aim to address these challenges through automation and eco-friendly technologies. Solar-powered seed-sowing machines, for instance, provide an environmentally conscious approach to mechanized planting. Autonomous and semi-automatic robots save time and labor while enhancing planting precision. Additionally, semi-automatic systems balance manual and automated operations, offering flexibility and efficiency. These advancements lay the groundwork for robotic seeding technologies that reduce labor demands and improve agricultural precision.

Building on these developments, this project introduces an autonomous seed-sowing robot designed to enhance efficiency and accuracy in farming. The robot utilizes a metal plough for ploughing and a rotater mechanism for controlled seed dropping, managed by an Arduino Mega microcontroller. Servo motors handle seeding, and DC gear motors with Encoder ensure stable navigation, supported by an TOF sensor for obstacle detection. By integrating IoT technology, the robot offers a robust and flexible solution for modernized planting. This innovation is anticipated to increase crop yields, reduce environmental impact, and streamline farming practices, paving the way for sustainable, high-efficiency agricultural operations.

KEYWORDS: Seed Dropping Mechanism, PID Control, DC Gear Motors with Encoder, TOF Sensor (Time of Flight)

I. INTRODUCTION

Agriculture plays a vital role in the Indian economy, employing over half of the population and contributing significantly to national GDP. However, despite its importance, many farming practices especially those related to seed planting remain traditional, inefficient, and heavily dependent on manual labor. These outdated methods often result in inconsistent seed spacing, irregular sowing depth, and delayed planting cycles, which collectively contribute to suboptimal crop yields, increased resource consumption, and heightened environmental impact. To overcome these challenges, there is a growing demand for automation in agriculture. Precision farming, driven by robotics and intelligent systems, has emerged as a key solution to improve productivity, reduce human effort, and optimize input usage. This project focuses on the development of an autonomous four-wheel-drive seed-sowing robot, referred to as the Agribot, specifically engineered to automate the sowing process with enhanced precision and efficiency. The proposed Agribot is designed to automatically plant seeds at defined intervals across a given field length and width, based on user-defined parameters such as row spacing and seed distance. It integrates components like servo motors for seed dispensing, encoder-based motor control for accurate movement, a TOF sensor for obstacle detection, and an Arduino Mega microcontroller for central control. Additionally, the robot is built on a robust chassis with optimized ground clearance to handle uneven terrain, reducing soil drag and improving mobility.

The traditional workflow in manual seed sowing involves several localized agricultural practices, notably Perani, which refers to the entire process of planting seeds into the soil using either manual methods, traditional tools, or modern machinery, and Tokani, which denotes the manual act of dropping seeds into furrows or holes, typically

coordinated with furrow creation using a pointed stick or plough. In the developed autonomous seed- sowing robot, the Tokani process is automated through the integration of a servo motor that precisely drops seeds at intervals defined by the user, thereby enhancing sowing accuracy, reducing manual labor, and improving operational efficiency. For optimal crop growth, spacing between plants is crucial, and it has been recommended that crops such as wheat, jowar, and bajra be spaced at 15–30 cm, while methi, dhanian, and spinach require 12–15 cm spacing, as detailed in the accompanying table. The robot has been engineered to function effectively across a variety of Indian soil types, where performance is influenced by traction, resistance, and seed placement accuracy. Loamy soil, with its balanced composition, provides optimal traction and seed germination conditions, while sandy and silty soils enable smooth movement with moderate resistance, though sandy soils may necessitate deeper furrows. Red soil, known for its loose texture, allows efficient robot operation with minimal wheel slippage. In contrast, clay-rich soils such as black cotton soil present high rolling resistance, particularly under wet conditions, potentially impacting robot mobility and necessitating improved wheel grip or tread design. Overall, firm and well-drained soils specifically loamy, sandy, silty, and red have been identified as the most suitable for efficient and precise operation of the autonomous seed-sowing robot.

The primary objectives of this project include automating the seed-sowing process to reduce labor dependency, ensuring consistent seed placement and spacing for uniform plant growth, enhancing sowing speed and field coverage without sacrificing precision, providing real-time monitoring and potential for IoT-based data logging. By achieving these goals, the Agribot is expected to significantly improve sowing accuracy, reduce human fatigue, and increase agricultural output. The relevance of this work extends beyond engineering, addressing pressing socio- economic issues such as labor shortages, the need for sustainable farming, and rural empowerment. Furthermore, the project serves as a foundation for future advancements in smart agriculture. With potential upgrades like GPS- based navigation, AI-driven decision-making, and cloud-based data analysis, the Agribot can evolve into a fully integrated precision farming system. Thus, this innovation is not just a step toward agricultural mechanization, but a leap toward a more sustainable and technologically empowered future for farmers in India and globally.

II. LITERATURE SURVEY

In 2017, Automatic Seed Sowing Machine Using Solar Panel presented a machine utilizing solar energy to automate seed sowing, providing an eco-friendly solution for agricultural challenges by integrating renewable energy into agricultural machinery [1]. Abdulrahman, Mangesh Koli, Umesh Kori, and Ahmadakbar also explored a seed-sowing robot in 2017, detailing a design aimed at saving time and labor for farmers [2]. In 2020, Cihan Yurtsever, Yasin Ertas, Oben Sustam, and Cenik Ulu discussed a robot for row-type seed sowing, emphasizing how robotics could streamline operations like crop planting [3]. Jayakrishna P.V.S., Suryavamsi Reddy M., Jaswanth Sai N., and others in 2018 designed an autonomous seed-sowing robot suitable for large-scale farming, addressing labor-intensive manual sowing processes [4]. Mosam K. Sangole, Dipak P. Patil, Ketan A. Dhamane, Rohit K. Jathar, and Rushikesh S. Kardile (2020) developed a semi-automatic seed sowing robot, bridging the gap between manual and fully automated systems to offer flexibility and efficiency [5]. Mrs. L. Sheela and M. Priyadarshini (2015) introduced a command-based self-guided rover for seed sowing, designed for user-friendly control [6]. In 2020, Neha S. Naik, Virendra V. Shete, and Shruti R. Danve focused on precision agriculture with a robot for accurate seed sowing, enhancing yields and reducing waste [7]. P. Baladarshini, S. Monika, N. Dhanalakshmi, and Dr. A. Asha (2017) fabricated a universal seed sowing machine adaptable to various crop types and soil conditions, addressing limitations of existing systems [8]. Palepu V. Santhi, Nellore Kapileswar, Vijay K. R. Chenchela, and Venkata Siva Prasad (2017) proposed a sensor and vision-based AGRIBOT to improve seed sowing precision [9]. Prajith A.S., Nowfiya B.S., Nadeem Noushad, and others (2020) introduced Agrobot, a multi-purpose agricultural robot designed to reduce manual labor [10].

Prasanna Raut, Pradip Shirwale, and Abhijeet Shitole (2016) explored a farmer-friendly robot using Zigbee technology for efficient communication in agricultural applications, aiding tasks like planting and crop monitoring [11]. Ratnesh Kumar, Aadhar Govil, Parth Daga, Shubh Goel, and Saurabh Dewangan (2022) presented an automatic seed sowing machine to meet the growing demand for automation with improved speed and accuracy [12]. Senthilnathan N., Shivangi Gupta, Keshav Pureha, and Shreya Verma (2018) designed a seed sowing machine with IoT technology for enhanced monitoring and control [13]. Shivaprasad B., Ravishankara M., and B.N. Shoba (2018) presented a multi-functional agricultural robot combining seeding and fertilizing capabilities [14]. Smita

N. Solanki, R.T. Ramteke, and Pragati S. Dhande (2022) focused on a machine to reduce human effort and improve seed placement precision [15]. Tanmay Nagdeve, Pranay Jangde, Hrushikesh Tandulkar, Sushobhit Dhara, Neema Ukani, and Saurabh Chakole (2020) designed a robot for BT cotton seed sowing with technologies for efficient operation [16]. T. Tirupal and D. Rajasekhar (2022) introduced a machine integrating seed, fertilizer, and water drip functionality to improve crop yield [17]. Bhushan Deshmukh and Durgesh Verma (2017) described an automatic seed sowing machine to increase efficiency and reduce manual labor [18]. Finally, Vidya Yedave, Punam Bhosale, Jyoti Shinde, and Prof. Jagdish Hallur (2019) explored an automatic seed sowing robot, emphasizing the role of robotics in agriculture and revisiting the concept for potential improvements in agricultural practices [19, 20].

III. SYSTEM ARCHITECTURE

The proposed seed-sowing robot integrates five key components that coordinate to enable autonomous and precise operation. Central to the system is the Embedded Control Unit, based on an Arduino Mega, responsible for motion control, seed dispensing, user interface handling, and obstacle detection. Locomotion is achieved using encoder-equipped DC gear motors, regulated through a PID algorithm to maintain accurate speed and travel distance, ensuring consistent seed spacing. A servo motor-driven Seed Dispensing Mechanism releases 2–3 seeds at user-defined intervals, enhancing uniformity. Obstacle Detection is managed by a VL53L0X Time-of-Flight sensor, which halts the robot and triggers a buzzer when an obstruction is detected within 200 cm, resuming operation once cleared. A 4×3 matrix keypad and 16×2 LCD form the User Interface, enabling parameter input and real-time feedback on system status, sowing progress, and alerts. The system's modular design ensures real-time responsiveness, with coordinated control across motion, dispensing, and safety functions.

The chassis of the autonomous seed-sowing robot has been designed to maintain optimal ground clearance, ensuring stability while allowing navigation over uneven terrain, furrows, and minor obstacles as shown in Fig. 1. This elevation minimizes soil accumulation around mechanical parts, improves durability, and supports seamless integration of sensors, seed dispensers, and wiring without affecting mobility or accuracy. Design considerations follow agricultural robotics standards emphasizing stability, maneuverability, and modularity [16]. The seed-dropping mechanism in Figs. 2, 3 consists of a seed holder and a servo-driven rotating rotor. Seeds are held in the reservoir, and 2–3 are released per cycle as the rotor, designed with grooved slits, aligns with the outlet and drops seeds by gravity. The servo rotates the rotor by 120° after each drop, ensuring consistent spacing. The mechanism enables precise seed placement, minimal wastage, adjustable spacing through servo control, and mechanical simplicity. Together, the chassis and dispensing system provide a reliable and scalable solution for automated precision sowing.



Fig. 1: Chassis Design of the Autonomous Seed-Sowing Robot

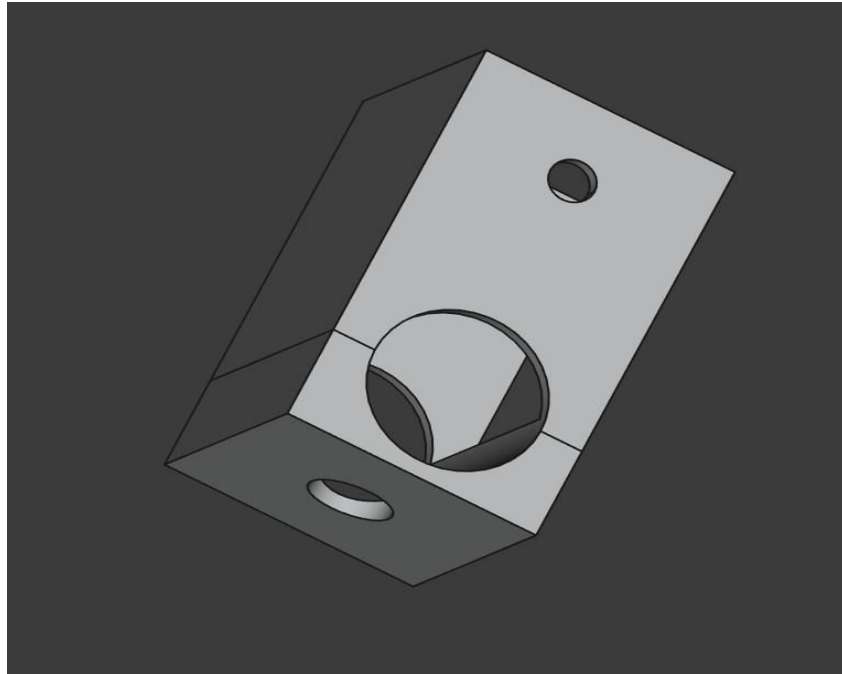


Fig. 2: Seed Sowing Mechanism - Holder

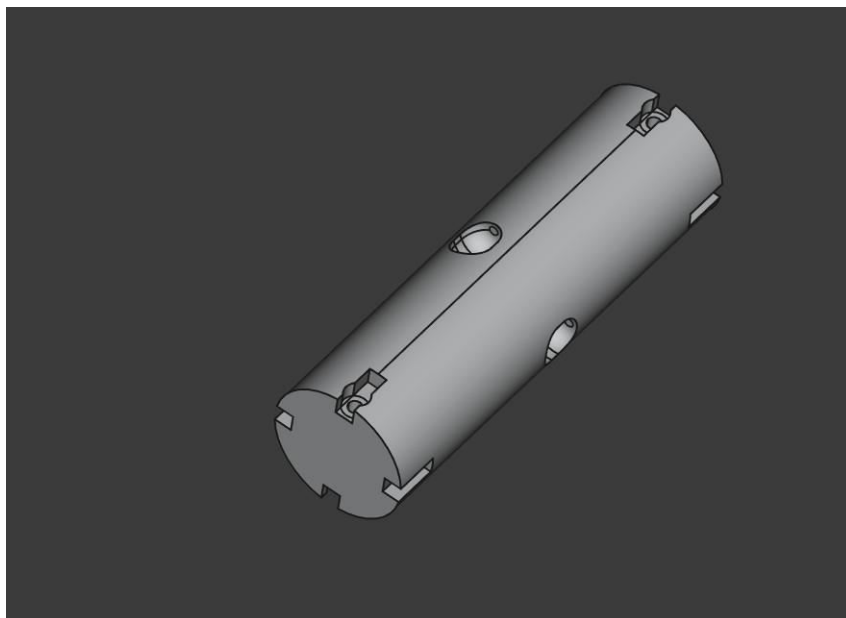


Fig. 3: Seed Sowing Mechanism - Rotater

IV. WORKING PRINCIPLE

The autonomous seed-sowing robot automates the seed planting process with precise motion control, seed dispensing, and obstacle detection. The system consists of several key components, as illustrated in Fig. 4. The block diagram illustrates an automated seed sowing robot designed to simplify and enhance the efficiency of the planting process. The core of the system is an Arduino Mega micro controller, which serves as the central processing unit, coordinating inputs

and outputs for various components. Power is supplied by a battery that ensures all modules, including sensors, motors, and the microcontroller, operate seamlessly. The system receives user inputs via a keypad, allowing farmers to set parameters such as planting distance and speed. Additionally, the robot is equipped with TOF (Time of Flight) sensor positioned to detect obstacles and measure distances accurately. These sensors continuously send real-time data to the microcontroller, enabling the robot to avoid collisions. If an obstacle is detected, the buzzer will turn on. Information about the robot's status, such as planting progress and error notifications, is displayed on an LCD screen connected to the Arduino, providing user-friendly feedback.

The movement of the robot is managed by a motor driver (L298), which controls the left and right wheels based on commands from the microcontroller. The motor driver receives processed signals and adjusts the speed and direction of the wheels to navigate the field efficiently. For the planting mechanism, a servo motor operates a precise seed-dropping system that releases seeds at predetermined intervals, ensuring uniform distribution. As the robot moves forward, a plough attached to the chassis creates furrows one inch deep for the seeds, and a flap follows to cover the seeds with soil, completing the planting process. This integrated approach leverages sensor inputs, motor control, and real-time feedback to perform automated planting with minimal human intervention. The design not only reduces manual labor but also improves accuracy and consistency in seed placement, making it a valuable tool for modern agriculture.

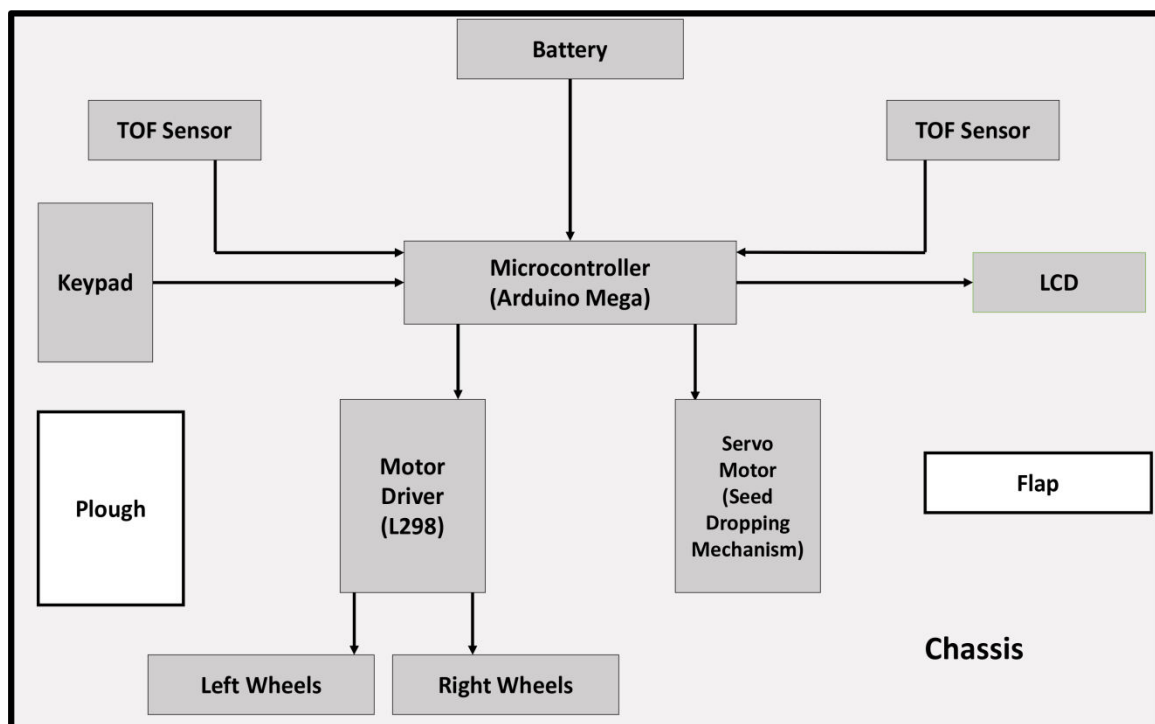


Fig. 4: Block Diagram of the Autonomous Seed-Sowing Robot

The autonomous seed-sowing robot is designed to make the planting process easier and more efficient by automating movement, seed dropping, and obstacle detection. The user simply enters the desired seed spacing and total field length using a 4×3 keypad, and the inputs are shown on a 16×2 LCD for confirmation. The robot moves over tilled agricultural soil, usually soft to moderately compacted, using rugged wheels that provide good stability and grip. It moves forward with the help of encoder-controlled motors, and a PID algorithm ensures it stops precisely at the right intervals based on the spacing entered. A PWM motor driver adjusts the motor's speed and direction for smooth movement. When the robot reaches the correct spacing, a servo motor triggers the seed dropper to release a seed into the shallow trench(furrows) of depth one inch made by a plough. Right after that, a soil flap at the back closes the

furrow. To avoid collisions, a VL53L0X time-of-flight (TOF) sensor constantly checks for obstacles up to 200 cm ahead. If something is detected within 60 cm, the robot stops and sounds a buzzer until the path is clear. This process keeps repeating until the robot finishes the programmed field length. At that point, it displays a 'Field End Reached' message on the LCD and activates the buzzer to let the farmer know. The system helps ensure seeds are planted evenly and accurately, with very little need for manual work.

V. RESULTS

The seed sowing robot was tested on a 10-meter long tilled field, dropping seeds every 20 cm at a depth of one inch. It worked well on tilled soil as shown in Table 1, kept proper spacing, and handled different soil types and small obstacles with ease. The Fig. 5 shows the working prototype of seed sowing robot.

Table 1: Performance Observations of the Seed-Sowing Robot

Parameter	Observation / Performance
Soil Types Tested	Worked well on loamy, sandy, silty, and red soils. In tightly packed or slightly wet areas, it had minor slips but quickly regained control.
Field Conditions	Tested on fields with uneven patches and mild slopes. Maintained performance with minor corrections.
Seed Spacing Accuracy	Maintained spacing of 20 cm \pm 5 cm even on rough terrain using PID-controlled wheel encoders.
Field Length Tested	Covered a 10-meter test plot, customizable based on user input.
Seeds Dropped	100–120 seeds dropped accurately in each run; 2 instances of minor misalignment due to bumps.
Obstacle Detection	The TOF sensor reliably spotted rocks, robot stopped and the buzzer went off immediately to alert.
Battery Performance	Operated continuously for 1.5 hours with load of 2kg (chassis + components); covered approx. 2 km in field conditions.
Durability & Stability	Chassis handled small obstacles and soil clumps without tipping or losing direction.
Overall Result	Robust and reliable performance in both ideal and challenging farm conditions with minor, recoverable deviations.

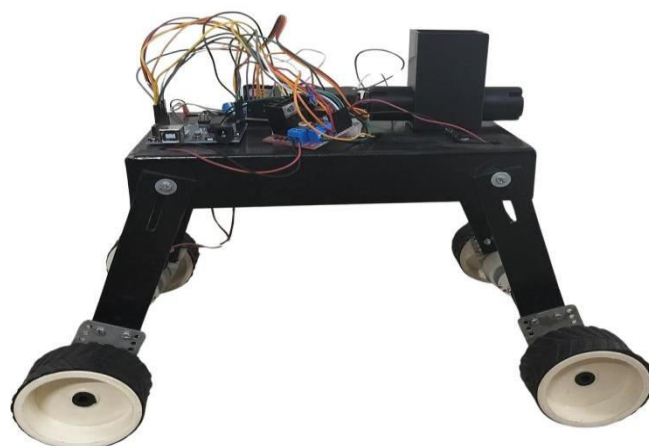


Fig. 5: Autonomous Seed-Sowing Robot Prototype

VI. CONCLUSION

The autonomous seed-sowing robot efficiently automates the seed planting process by integrating precise motion control, seed dispensing, and obstacle detection. The use of an encoder-based PID control system ensures accurate speed regulation and positioning, while the servo-driven seed dropping mechanism drops the seeds at accurately.

Real-time monitoring via TOF sensors enhances safety by preventing collisions, and the user-friendly interface allows easy customization of field parameters. This design minimizes manual labor, increases efficiency, and enhances precision in agricultural operations. Future enhancements may include GPS-based navigation, adaptive seed rate control, and integration with IoT for remote monitoring and data logging.

To achieve full automation, the seed-sowing robot can be enhanced using Artificial Intelligence (AI) and the Robot Operating System (ROS). AI-based computer vision may be used for detecting soil conditions, obstacles, and ideal seed placement zones. Path planning and seed dispensing can be optimized through reinforcement learning. GPS and IMU integration would allow precise autonomous navigation. A ROS-based modular architecture can ensure reliable communication between sensors and actuators, while IoT connectivity can enable real-time monitoring and remote operation. Future enhancements may include solar power integration to reduce battery reliance and support sustainable farming in remote areas.

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