International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 12 December 2025
Page No: 4423-4426
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2025.0650

Autonomous Seed Sowing Robot with Slam Based Precision Navigation

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Abstract
The main objective of the project is to create autonomous seed sowing robot integrated with simultaneous localization and mapping (SLAM). This multidisciplinary project combines various hardware components, such as a microcontroller, light and sound sensors, communication modules, rotatory system and a power supply, all integrated into a robust frame. Motor driver and a micro controller-based control unit manage locomotion and seed dispensing mechanisms. The SLAM algorithm enables the robot to navigate autonomously in varying terrains, maintain straight sowing paths and record planting locations for future reference. C++ and python programming environments are utilized for sensors data processing, control logic and mapping operations. It aims to automate the seed sowing process with high accuracy, reducing human effort and increasing productivity in agricultural operations.
Keywords: *Autonomous Robot, Seed Sowing, LIDAR, Micro Controller, Motor Driver, SLAM, Obstacle Detection, Motor Control, Path Planning, ROS.*

1. Introduction
An autonomous seed sowing robot with SLAM-based precision navigation addresses the major challenges in modern agriculture by combining robotics, automation, and intelligent mapping techniques. The background of this project is grounded in the rising demand for efficient and sustainable farming, as traditional manual sowing is labour-intensive, often imprecise, and subject to human error, affecting crop yields and resource utilization. The agricultural sector faces significant pressures due to a growing population, limited labour availability, and the necessity to maximize crop yields using minimal resources. Conventional methods of seed planting, which rely heavily on manual labour, are slow, inconsistent in seed distribution, and can result in uneven germination and poor crop spacing. Automation has emerged as a solution, with autonomous robots streamlining the sowing process and improving accuracy in seed placement—including distance, depth, and intervals—across various soil conditions. Integrating SLAM (Simultaneous Localization and Mapping) allows the robot to navigate and map fields with precision, avoid obstacles, and ensure full coverage without gaps or overlap. The motivation for developing an autonomous seed sowing robot is twofold: to address the inefficiencies and high labour demands of traditional sowing and to harness advanced robotics for sustainable agricultural growth. This project leverages modern components, such as microcontrollers, sensors, and intelligent navigation algorithms, ensuring the robot can adapt to field variations and optimize seed placement automatically. By reducing human intervention, the robot helps minimize labour costs, seed wastage, and inconsistencies, while also allowing scalable operations on different field sizes. Ultimately, this innovation aims to promote modern, technology-driven farming practices that are efficient, resource-optimized, and capable of meeting future food demands sustainably [1-4].

1.1. Problem Statement
Traditional manual seed sowing is labour-intensive, time-consuming, and often results in uneven seed placement and wasted resources. There is a need for an autonomous, SLAM-enabled seed sowing robot that can navigate fields with precision, optimize seed distribution, and reduce human labour, ultimately leading to increased productivity and sustainability in agriculture [5-10].

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1.2. Objectives of the Project

The main objectives of this project are

- Automate the seed sowing process to reduce manual labor and increase efficiency.
- Achieve precise and uniform seed placement at user-defined intervals and depths.
- Enable autonomous navigation and field coverage using SLAM for obstacle avoidance and accurate mapping.
- Reduce overall planting time and improve productivity in agriculture.
- Integrate advanced sensing and control technologies (such as Arduino and Raspberry Pi) for real-time decision-making and automated operation.
- Increase sustainability and support modern, technology-driven farming practices.

1.3. Scope of the Work

The scope of the autonomous seed sowing robot project includes the design, development, and testing of a fully automated system capable of precisely planting seeds with minimal human intervention. The project covers the integration of sensors, microcontrollers, and mechanical components to control seed spacing, depth, and distribution. The robot will be adaptable to different soil types, seed varieties, and field conditions, and can be further enhanced for tasks like fertilization and irrigation in the future, table 1 [11-18].

Table 1 Software and Tools Used

Software/ Tool	Function
Arduino IDE	For programming and uploading code to the microcontroller.
Python	For implementing and simulating the SLAM algorithm.
TinkerCAD/Proteus	For circuit design and simulation of hardware connections.
Solid works	For designing the mechanical structure of the robot.
Python language	For coding control logic
	and data processing.
ROS	For operating robot and simulations.
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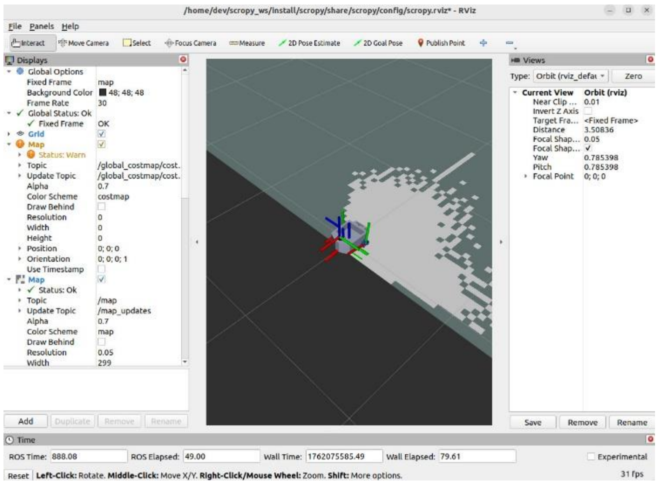

Figure 1 Simulation of Autonomous Seed Sowing Robot

2. Results and Discussion

2.1. Results

The prototype autonomous seed sowing robot was evaluated in a controlled field environment to assess its ability to perform precision navigation and seed planting. During testing, the robot successfully mapped the field using SLAM algorithms and accurately followed the planned sowing path with minimal deviation from the set trajectory. Seed dispensing performance remained consistent, achieving a placement accuracy of over 90 percent at

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the specified intervals. Obstacle avoidance using real-time sensor data was reliable, allowing the robot to detect and navigate around sudden obstacles without disrupting the sowing pattern, Figure 1.

2.2. Discussion

Based on the evaluation results, the robot demonstrates strong potential for reliable field deployment. Its accurate navigation, high seed placement precision, and effective obstacle avoidance indicate that the system meets the expected performance standards and is suitable for further development or field-scale trials, Figure 2.

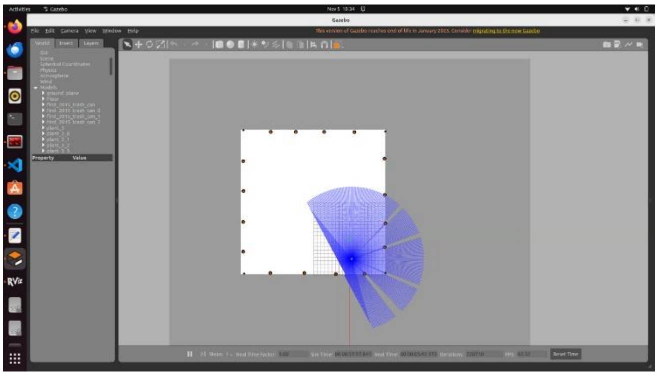

Figure 2 Graphical Representation of Simulation

Conclusion

The development of an autonomous seed sowing robot with SLAM-based precision navigation provides an effective solution to many limitations of traditional sowing methods. By integrating intelligent mapping, autonomous navigation, and automated seed dispensing, the system improves accuracy, efficiency, and consistency in seed placement. The project demonstrates how modern technologies such as microcontrollers, sensors, and SLAM algorithms can work together to reduce human labour, minimize resource wastage, and enhance overall field productivity. The robot's ability to adapt to different field conditions, avoid obstacles, and maintain precise sowing intervals ensures reliable operation and supports sustainable, technology-driven farming practices. This work also provides a foundation for future improvements, including the addition of advanced functions such as fertilization, irrigation, and crop monitoring to further strengthen smart agricultural systems.

Acknowledgements

I express my sincere gratitude to all those who supported and guided me throughout the development of this autonomous seed sowing robot project. I extend my heartfelt thanks to my project supervisor for providing valuable insights, encouragement, and continuous guidance, which greatly contributed to the successful completion of this work. I am also thankful to the faculty members and my seniors for offering the necessary resources, technical assistance, and a conducive environment for experimentation and testing. I wish to acknowledge the support of my peers and friends for their cooperation and constructive suggestions throughout the project duration. Finally, I am deeply grateful to my family for their constant motivation, understanding, and support, which enabled me to pursue and complete this project successfully.

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