Solar-Powered Smart Agricultural Rover for Precision Farming

Andure Janhavi[1], Avhad Harshali[2], Bhosale Sarang[3], Borse Sayali[4], Chavan Shashwati[5], Jadhav Dhruv[6], Kasar Nandan[7], Pawar Om[8], Mr.M.A.Nalawade Project Guide[9], Mr.N.R.Thakare[10]
HOD of Electronics and Telecommunication Engineering Department [10]
[1,2,3,4,5,6,7,8,9,10]*Department of Electronics and Telecommunication Engineering SNJB's Shri. Hiralal Hastimal (Jain Brothers, Jalgaon) Polytechnic, Neminagar, Chandwad.*

Abstract*— Agriculture remains the foundation of human survival, yet conventional farming practices are often labor-intensive, resource-demanding, and inefficient. To address these challenges. The Solar-Powered Smart Agricultural Rover is developed as a sustainable and automated solution for modern farming. The system integrates solar energy, microcontroller-based automation, and real-time monitoring to perform key agricultural tasks, including seed sowing, soil moisture detection, environmental monitoring (temperature and humidity), and spraying for irrigation or pesticide application. Controlled via an RF-based communication module, the rover enables precise operation in both manual and semi-autonomous modes. Its solar-powered design makes it eco-friendly and highly suitable for remote areas with limited access to electricity. By ensuring accurate seed placement, optimized water and pesticide usage, and reduced human effort, the proposed rover enhances productivity, conserves resources, and promotes sustainable precision farming.

Keywords – (Solar-powered rover, Smart agriculture, Precision farming, Microcontroller, Seed sowing, Soil moisture monitoring, RF communication, Irrigation, Pesticide spraying, Renewable energy.)

I. INTRODUCTION

Agriculture is the backbone of human survival, but traditional farming methods are often labor-intensive, time-consuming, and inefficient in terms of seed placement, irrigation, and pesticide use. With the growing demand for sustainable and precise farming, automation and renewable energy technologies are being integrated into the agricultural sector.

The Solar-Powered Smart Agricultural Rover is a microcontroller-based robotic system designed to perform essential farming tasks, such as seed sowing & real-time monitoring (soil moisture, temperature & humidity), with an additional spraying mechanism that achieves high efficiency and reduces human effort. Powered by solar energy, the rover becomes eco-friendly and suitable for precise farming and remote areas with limited electricity access.

The rover operates on a microcontroller unit (such as Arduino/ATmega32A), which acts as the brain of the system. It receives commands from an RF remote through an RF receiver module for manual or semi-autonomous control. The robotic drive motors allow smooth movement across

Farmland, while the seed sowing mechanism ensures precise seed placement at uniform intervals. A soil moisture sensor continuously monitors field conditions, enabling the system to activate the spray pump for irrigation or pesticide application when required.

By integrating renewable energy (solar power), automation (microcontroller control), and remote operation (RF communication), the system ensures precision farming**,** conserving resources such as seeds, water, and fertilizers, while improving crop yield and reducing labor dependency.[1][2]

II. LITERATURE REVIEW

The study by Ayanniran F. (2024) on a Robotic Maize Seed Planter focused on developing an automated system for accurate maize seed sowing. The author introduced a hopper with a metering disc mechanism and an encoder-based seed sowing system, which improved precision in spacing and seed placement. Another related research titled "Design and Fabrication of Solar Powered Autonomous Seed Sowing Vehicle" (2025) proposed a solar-powered robotic seeder that combined renewable solar energy with multi-functional modules for seed sowing and spraying, enhancing efficiency in agricultural

processes. Zhang X. (2024) conducted a technology review on soil moisture sensing, comparing capacitive and resistive sensors, and highlighted the importance of proper calibration for improving measurement accuracy in smart irrigation systems. Additionally, Khadatkar et al. (2023) developed a compact robotic transplanter designed for precision seedling planting, which utilized robotic arms to achieve high positional accuracy, reducing manual labour and improving consistency. Furthermore, NI myRIO Educational Prototypes (2017–2024) contributed significantly to agricultural robotics research by providing an embedded control platform based on FPGA and ARM architecture using LabVIEW, which has been widely applied in student projects involving seed sowing and spraying automation.

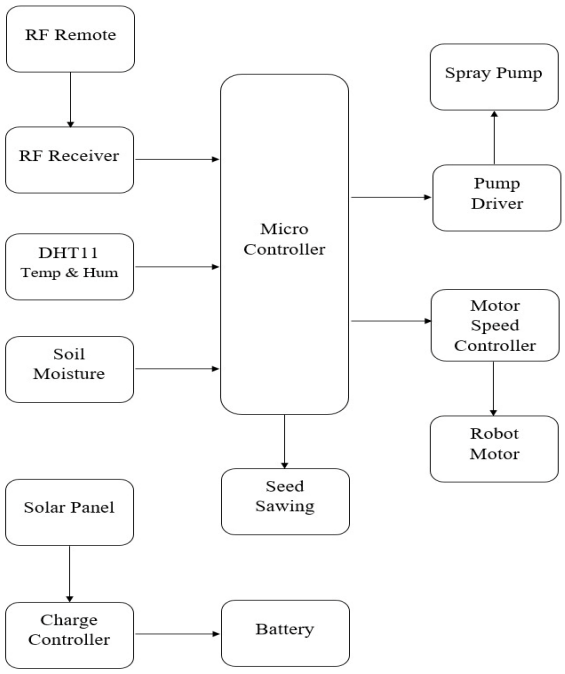
III. AUTOMATIC SEEDS PLANTATION

In addition to seed sowing, multipurpose operations such as Leveling & Plugging are also needed. But most of the problems are faced by farmers during the seed sowing operation, like proper adjustment of the distance between two crops, the distance between two rows, etc. Seed sowing is a very basic and paramount operation in the agricultural field. Nowadays, seed sowing is done either manually or by tractors. The manual method includes broadcasting the seeds by hand. Sometimes, the method of dibbling, i.e., making holes and dropping seeds by hand, is used. Also, a pair of bullocks is used to carry the heavy equipment for leveling and seed dropping.

Our system is nothing but a four-wheeled vehicle that is driven by a geared DC motor. According to the My Rio program, after some distance or some time interval, the seed should be dropped through the pipe, and the leveling process will be done sequentially.

Connect the myRIO to the nearby Wi-Fi network. Initially, the robot will drop the seed. Next, it moves 1 foot ahead, and step 2 will be repeated. Step 3 will be repeated until the row is completed. Now the robot stops Sowing and turns 180 degrees right. Again, steps and 5 will be repeated until the field completes its seed sowing. [1][3][4]

IV. BLOCK DIAGRAM



V. WORKING

The system is powered by a solar panel, which charges a battery through a charge controller to provide a regulated DC supply to all modules. A microcontroller functions as the central processing unit, receiving inputs from the RF receiver, soil moisture sensor, and temperature and humidity sensor. The RF remote enables wireless manual control, while the soil moisture and environmental data are used for automated decision-making. The microcontroller generates control signals for various actuators: it drives the robot motors through a motor speed controller for navigation, activates the seed sowing mechanism for controlled seed placement, and operates the spray pump via a pump driver for irrigation or pesticide spraying. Thus, the integration of renewable energy, wireless communication, sensor feedback, and electromechanical actuators allows the rover to perform precision farming tasks autonomously and efficiently.

VI. SPECIFICATIONS OVERVIEW

Component	Specification
Solar Panels	2 × 20 W (12 V), 290×280 mm

	each; total 40 W
Charge Controller	12 V systems, up to 20 A, ~1 kg
Battery	12 V, 14 Ah, ~6 kg
Drive Motor	12 V DC hub, 250 W, ~25 rpm output
Steering Motor	12 V DC window motor, polarity-switch steering
Pump	12 V, 60 W, 5 L/min, ~800 kPa
Tank	10 L, ~10 kg
Nozzle Spray Range	Adjustable, ~1.5 m
Controller	ATmega32A microcontroller, Bluetooth HC-05
App Control	Android, toggle & directional control (~130 ms latency)
Spray Duration & Range	4 min or ~159 m per full tank

VII. FEATURES

1. Eco-friendly power – Uses renewable solar energy, reducing fuel costs and pollution.
2. Automation of farming tasks – Performs seed sowing, spraying, and soil monitoring with less human effort.
3. Precision farming – Ensures proper seed spacing and depth, improving crop yield.
4. Water efficiency – Soil moisture sensor ensures spraying/irrigation only when needed.
5. Remote operation – RF remote or wireless control allows easy handling from a distance.

VIII. RESULT

Component / Function	Specification / Value	Result / Outcome
Solar Panels	2 × 20 W (12 V), 290×280 mm each (40 W total)	Supplied stable renewable power through a charge controller
Battery	12 V, 14 Ah (~6 kg)	Provided continuous backup for rover operation
Charge Controller	12 V system, up to 20 A (~1 kg)	Maintained regulated charging and protected the battery
Drive Motor	12 V DC hub, 250 W, ~25 rpm	Ensured smooth and powerful rover movement
Nozzle Spray Range	Adjustable, ~1.5 m	Achieved uniform and efficient spraying
Controller	ATmega32A + Bluetooth HC05	Controlled sowing, spraying, and navigation
App Control	Android app (~130 ms latency)	Enabled remote directional + toggle control
Seed Sowing Unit	typical ranges: 10–15 cm	Achieved proper and uniform seed spacing

IX. CONCLUSION

The solar-powered smart agricultural rover successfully integrated seed sowing, soil moisture detection, spraying, and remote-controlled navigation. It demonstrated efficient use of renewable energy, reduced human effort, and improved precision in basic farming tasks.

X. FUTURE SCOPE

AI-based decision-making for crop management, and larger battery storage for extended operation. The spraying system of the rover can be enhanced with automated target spraying to apply pesticides only where needed, variable rate spraying to adjust flow based on soil or crop conditions, and improved nozzle designs for better coverage and efficiency.

REFERENCES

[1] Shah, A., & Jain, R. (2023)- Design and development of an autonomous agricultural rover for planting and irrigation systems using TRIZ design principles. International Journal of Software & Hardware Research in Engineering, 11(10), 145–150.

[2] Ayyagari, S. T., Kizhakke Erakkat, S., TS, S., & Neerati, M. (2021). Design and fabrication of a solar-powered, remote-controlled, terrain sprayer and mower robot. arXiv.

[3] Islam, M. R., Rana, S., Kashem, A., & Ulla, O. (2023) A survey on solar-powered autonomous multipurpose agricultural robots. ResearchGate.

[4] Challa, T., Nirmala Nidhi, T., Karu, A., Rajesh, A., & Mounika, S. (2020). Development of a solar-powered autonomous agricultural robot controlled via Bluetooth and an

Android app. Journal for Educators, Teachers and Trainers, 11(1), 146–157.
[5] Sai Yaswanth, B., Pruthvi Raj, N., Rahul, B. P., & Murthy, B. T. V. (2022). Solar power-based agriculture robot for pesticide spraying, grass cutting, and seed sowing.
[6] R. P. Jain – Modern Digital Electronics.
[7] Muhammad Ali Mazidi - The 8051 Microcontroller and Embedded Systems.