Solar-Powered Autonomous Agricultural Robot for AI-Based Weed Management and Precision Seeding

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Abstract

In response to the growing need for sustainable farming, this project presents a Solar-Powered Autonomous Agri-Bot. The system integrates renewable energy with artificial intelligence to automate weed management and precision seeding. Using a dual-vision system and an on-board AI model, the robot distinguishes weeds from crops in real-time to perform localized spraying. Simultaneously, it executes a complete "plow-plant-close" cycle using mechanical soil manipulation tools. Powered by a solar-integrated battery system and featuring a custom web-based interface, the robot offers a self-sustaining solution that optimizes crop yields while reducing the carbon footprint of farming.

Keywords: Precision Agriculture, Autonomous Agri-Bot , Sustainable Farming

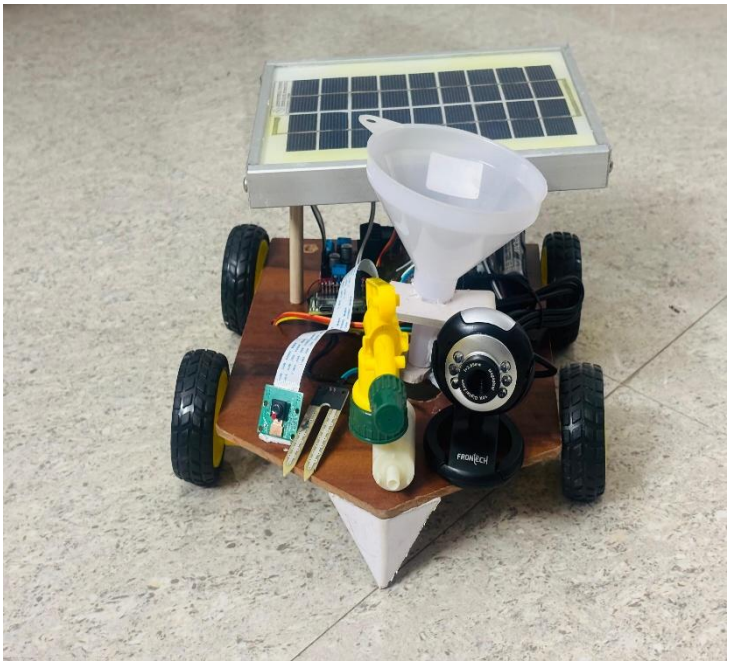
Working Process

The robot operates through a synchronized integration of vision, software logic, and mechanical actuation to manage field tasks autonomously.

Weed Detection and Targeted Spraying: The robot utilizes a dual-camera system to achieve a wide-angle field of view, covering two rows of crops simultaneously. An on-board AI model processes these video streams locally to identify weeds in real-time. Upon identification, the system activates a localized spray mechanism to apply fertilizer or herbicide directly to the weed, saving up to 80% of chemicals compared to traditional blanket spraying.

Precision Seeding and Soil Preparation: The planting process follows a three-stage mechanical cycle. First, a forward-mounted V-shaped tool opens a trench of consistent depth. Second, a high-precision dispenser releases seeds at mathematically determined intervals. Finally, a rear-mounted reverse V-shaped tool redirects displaced soil back into the trench to cover the seeds, protecting them from birds and the sun.

Soil Moisture Monitoring: To assist in irrigation management, the robot is equipped with a sensor that gauges the volumetric water content of the soil. Because the main controller lacks built-in analog reading capabilities, an



additional converter is used to translate these moisture levels into digital data for the system.

Mobile Operation and IoT Connectivity: Farmers interact with the robot through a local Wi-Fi hotspot created by the device itself. This allows the user to access a web-based dashboard on any smartphone or laptop to view live camera feeds, monitor soil moisture levels, and take manual override control without needing an internet connection.

Future Use

The Agri-Bot is designed for versatility across various agricultural sectors

- → **Small and Marginal Scale Farming:** It provides automation for farmers who cannot afford heavy machinery but need to manage labor-intensive tasks in narrow rows.
- → **Greenhouse and Polyhouse Monitoring:** Its compact size and local access point make it ideal for indoor environments where it can navigate between planters and monitor soil conditions.
- → **Experimental Research:** Agricultural universities can use the bot as a mobile data collection platform to map weed growth patterns and soil moisture over different seasons.

→ **Organic Farming:** For chemical-free environments, the spraying mechanism can be replaced with a mechanical weeding claw to physically remove weeds, maintaining organic integrity.

Conclusion

The Solar-Powered Autonomous Agri-Bot represents a significant advancement in Agriculture 4.0 by shifting decision-making from humans to machines. By combining renewable solar energy with edge AI, the project addresses the "Triple Threat" of labor scarcity, rising costs, and environmental degradation. This self-sustaining platform not only increases precision in seeding and weed management but also provides an affordable, high-tech tool for small-scale farmers to optimize their productivity sustainably.

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