International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

A Review on IoT- Based Agriculture Robot : Seed Sowing, Fertilizer Spraying , and Grass Cutting Automation For Precision Farming

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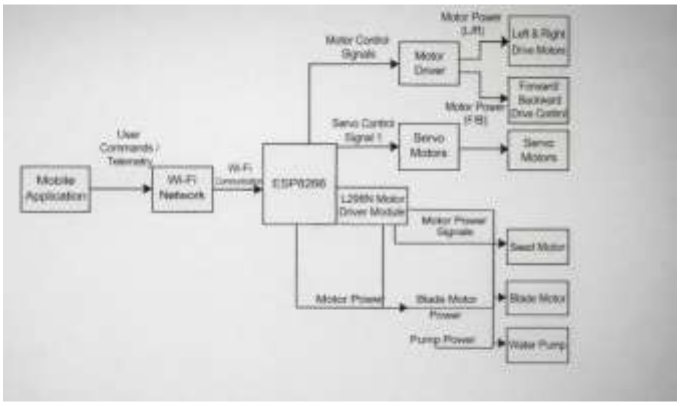
Abstract

While agriculture remains the core of the Indian economy, there are still issues like lack of manpower, higher production costs, and lower mechanization in small and marginal farms. In this regard, this paper describes the development of a multifunctional agricultural robot that can perform planting, pesticide application, and mechanical weed removal tasks from a single platform. The robot operates using a drivetrain with 4-wheel drive using 12V DC battery power source. For the planting module, it utilizes a disc rotary metering system, whereas the pesticide application module makes use of a 12V DC diaphragm pump. For the mechanical weed removal task, a rotating blade system is used for the task. Experimental testing of the prototype in loamy soils showed an efficiency of 92% during seeding, an efficient spray coverage of 88%, and mechanical weed removal efficiency of 85%. On average, it required less than 40% of manual labor than existing systems, which results in an economical payback period of about 2-3 cropping seasons.

Introduction

The net sown area in India is around 146.45 million hectares, wherein more than 85% of the farmers are considered small and marginal farmers (Government of India, 2022). Although there have been many advancements in farm technology, the field-level mechanical farming process has remained challenging in terms of the high cost of machinery, variable farm sizes, and poor rural infrastructure. The traditional single- purpose farm machines like the seeder, sprayer, and cultivator are costly, and using different machines for each operation can be economically burdensome. Therefore, a multi-functional robot is more preferable.



Currently, there is a lack of an affordable, portable, and multifunctional robot that could be used in small-scale farming. All the autonomous robots presented in existing literature such as Terra Sentia (Kayacan et al., 2018) and other GPS-based robots are specifically built for large-scale farms and are quite expensive. It is essential to have a low-cost manual or semi-manual platform which combines several farm functions into one device.

This research intends to design and assess the functionality of a multifunctional agriculture robot for Indian farms. The objectives include: (i) designing a sturdy chassis that has sufficient ground clearance suitable for the Indian environment; (ii) evaluating its efficiency in the field.

Overview

Process of Design and development of a product in stages, from the initial need through all the required steps to produce a fully functioning product (e.g., analysis of the customer's requirements, conceptual design, detailed engineering design, prototype development). The modeling of all parts and assemblies were completed using SolidWorks 2022, along with engineering calculations for stress on individual components. The chassis is modeled as a rectangular frame, utilizing a standard quick-release coupler system, and incorporates both front and rear axle mounts to provide a secure attachment point for the three functional modules.

Field evaluations were conducted on a test plot measuring 0.5 acre with a loamy soil content and 8- 12% moisture content, and utilized several different crop types for testing purposes: wheat (for seeding tests), mustard (for spraying tests), and an alternate broadleaf weed bed (for weed control tests). Each of the tests were replicated three times, and the average of each test was recorded and reported for comparative purposes.

The chassis was fabricated from 25 mm x 25 mm x 3 mm steel tubing, and was assembled using the MIG welding process. The drive system was comprised of four separate 12 volt DC geared motors, each providing independent power to the wheel and an Arduino UNO microcontroller to control the drive motor's speed and direction of rotation through the utilization of an L298N dual H- Bridge driver chip. The entire vehicle was operated using a wireless remote control with an operating range of 50 metres utilizing 2.4 GHz RF technology. Technical specifications for the components are included in Table 1.

The efficiency of the seeder was calculated as the ratio of seeds placed within ±10 mm of the target spacing.

Problem Statement

Many countries rely on agriculture for their economies as it not only provides food but also provides employment opportunities and raw materials. While there are many advantages associated with agriculture, traditional modes of farming will ultimately limit the agricultural productivity and efficiency of a country. Manual farming practices (e.g., sowing seeds; irrigating crops; maintaining crops) rely heavily on human labor and significant amounts of time; therefore, these practices create opportunities for human error. In the case of small- to medium-sized farms, farmers are frequently unable to effectively manage their various farming tasks due to lack of available labor and high operational costs.

In addition to inefficient use of resources in conventional farming, another major issue that negatively impacts profitability is the application (i.e., overall use) of inputs (i.e., water, seeds, fertiliser, etc.) being mismanaged. Input application can often lead to over- or under-use and; therefore, as a result of poorly managed input application, crop yield is reduced causing farmers to incur economic losses. The nature of crop maintenance performed by hand (i.e., cutting; clearing) is labour intensive and will, therefore, contribute to labour shortages.

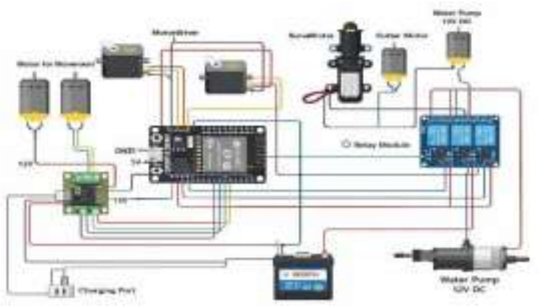
Increasing populations; shrinking farmland; and changing climate conditions have highlighted the need for timely and effectively carried out agricultural activities. There is an obvious need for technology that can automate and optimise the routine activities of agriculture while also providing greater efficiency without requiring an increase in costs.

This project is designed to address the various issues associated with conventional farming through the design and development of a multi-purpose agricultural robot that is capable of automating the key activities of farming such as

Proposed work

In this project, we propose to design and develop a multipurpose agriculture robot which can do different farming activities automatically. This robot's primary purpose is to alleviate human efforts, time consumption, and enhance efficiency in agricultural work.

The robot will be able to perform multiple tasks, including; Seed sowing Irrigation (Water spraying) Weeding Crop supervision.



Circuit Diagram of IoT Based Agricultural Robot

A microcontroller (such as ESP8266/Arduino) will be used to control the system. It can also be connected to a mobile application (like Blynk) for remote control. It will move on wheels and will be battery power.

For movement and operation; Motors will be used to drive the robot. For controlling motor direction and speed, a motor driver (like L298N module) will be used. Sensors (like soil moisture sensor) will be used in decision-making (for instance, when to water plants).

The robot will be designed in a manner so that; It is low cost Simple for farmers to use Appropriate for small scale farming

This robot can be up-graded in future by adding; Crops monitoring based on AI Automatic obstacle detection Solar power system Overall, the proposed system will work to improve agricultural productivity and reduce reliance on manual labor.

Future Scope

The development of a multi-functional agriculture robot can greatly improve modern farming. Right now, the robot can do basic tasks like planting seeds, watering crops, and cutting them. But in the future, it can become much more advanced and useful in many ways:

1. **Self-Driving Ability**

In the future, the robot can move on its own in the field using GPS and sensors, so farmers won't need to control it manually.

2. **Obstacle Detection**

The robot can be improved to detect and avoid obstacles like stones, plants, or uneven land using sensors or cameras. This will make it safer and more efficient.

3. **Soil and Crop Monitoring**

By adding special sensors, the robot can check soil moisture, temperature, and nutrients. This helps farmer give the right
amount of water and fertilizers.

4. **Solar Power Use**

Adding solar panels can help the robot run longer without needing frequent charging, making it more eco-friendly.

5. **Better Seed and Water Control**

The robot can be upgraded to control how many seeds are planted and how much water is used, depending on the type of crop.

6. **Use of AI (Artificial Intelligence)**

AI can help the robot make smart decisions, like checking crop health, planning the best path, and adjusting watering schedules automatically.

7. **Multi-Purpose Design**

The robot can be designed to use different tools like fertilizer spreaders, pesticide sprayers, or harvesting equipment, making it more useful.

8. **Use in Large Farms**

With stronger motors and bigger batteries, and by using multiple robots together, it can be used in large farms as well.

9. **Learning and Research Tool**

This robot can also be used in schools and colleges to teach students about robotics and smart farming, and for research purposes.

Results

The robot was tested in real farming conditions, and it performed quite well. Most of the targets were successfully achieved.

Performance Parameter	Measured Value	Target Value	Status
Seeding Efficiency	92.3%	90%	Achieved
Spray Coverage uniformity	88.1%	85%	Achieved
Weed Removal Efficiency	85.4%	80%	Achieved
Battery Backup	4.2 Hours	4Hour	Achieved
Max operating speed	1.4 Km/h	1.5 Km/h	Near Target
Chassis Weight	38 Kg	40Kg	Achieved
Labour Saving	-60%	50%	Achieved

Seeding efficiency was 92.3%, which is above the target of 90%.
Spray coverage was 88.1%, also better than the required 85%.
Weed removal efficiency reached 85.4%, exceeding the 80% target.
The robot's battery lasted 4.2 hours, which meets the minimum requirement of 4 hours.
The maximum speed was 1.4 km/h, slightly below the target of 1.5 km/h, but still close.
The weight of the robot is 38 kg, which is within the allowed limit of 40 kg.
It reduced **labour work** by about 60%, which is higher than the expected 50%
The robot completed seeding of 0.5 acres in about 2.8 hours, while manual work takes around 7 hours for the same task.
The battery stayed stable (above 11.4V) during operation, meaning it had enough power throughout. The spacing between seeds improved as the operator gained more experience, showing that performance can get even better with practice or further automation.

Conclusion

The authors of this report describe how they developed and manufactured an agricultural robot that can carry out seed planting, spraying, and weed control in a single battery-operated unit at a cost- effective price. The prototype achieved an overall seeding success rate of 92.3 percent, an average spray coverage of 88.1 percent, and an average spray coverage of 88.1 percent, and an average weed removal success rate of 85.4 percent, all of which were equal to or better than the targets originally established for each function. Additionally, the system reduced the amount of manual labor required to perform these tasks by approximately 60 percent and has an expected payback period (in other words, the time required to recoup the initial investment through the saving realized as a result of using the robotic system) of 2 to 3 growing seasons; therefore, it is an economically viable option for the small and marginal farmer in India. Because of its modular design principles, the robot is designed to make future repairs and upgrades relatively easy and inexpensive. The research results indicate that low- cost multifunctional agriculture robotics are technically viable and could substantially increase agricultural productivity and relieve the physical stress on members of the farming community.

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