Department of Mechanical Engineering – Coimbatore

Agricultural Robot

21ARE399 Mini Project Report

Submitted by

CB.EN.U4ARE22009 - Y. B Vignesh Mohan Reddy

CB.EN.U4ARE22011 - C. Anil Kumar

CB.EN.U4ARE22016 - G. Sathwik Reddy

CB.EN.U4ARE22025 - I. Bala Surya Prakash

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of

BACHELOR OF TECHNOLOGY

in

AUTOMATION AND ROBOTICS

AMRITA SCHOOL OF ENGINEERING, COIMBATORE - 641112

AMRITA VISHWA VIDYAPEETHAM
COIMBATORE 641112

BONAFIDE CERTIFICATE

This is to certify that this project report titled *"Agricultural Robot"* was submitted by

Y. B Vignesh Mohan Reddy	CB.EN.U4ARE22009
C. Anil Kumar	CB.EN.U4ARE22011
G. Sathwik Reddy	CB.EN.U4ARE22016
I. Bala Surya Prakash	CB.EN.U4ARE22025

to the Department of Mechanical Engineering, Amrita School of Engineering, Coimbatore, for the award of Bachelor of Technology in Mechanical Engineering, is a *bonafide* record of the work done by them under the mentorship of Dr Rammohan S, Associate Professor, Department of Mechanical Engineering. The contents of this report, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma**.**

Dr. Rammohan S
Associate Professor
Department of Mechanical Engineering
Amrita School of Engineering

Dr K Ramesh Kumar
Chairperson
Department of Mechanical Engineering
Amrita School of Engineering

Place: Ettimadai
Date:

This report was examined, and the candidates underwent Viva-Voce examination on

Examiner -1
Name

Examiner-2
Name

DECLARATION

I hereby declare that this project report has been written by us. We have not plagiarized any part of this report from any other sources. We have duly cited and referenced all the information included from other sources. We declare that if any part of the report is found to be plagiarized, we shall take full responsibility for it.

Y. B Vignesh Mohan Reddy
CB.EN.U4ARE22009

G. Sathwik Reddy
CB.EN.U4ARE22016

C. Anil Kumar
CB.EN.U4ARE22011

I. Bala Surya Prakash
CB.EN.U4ARE22062

Dr. Rammohan S
Associate Professor

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Abstract

Automation in agriculture has gained much demand, and autonomous robotic systems have enhanced the efficiency and precision of farming operations. This project is designed to fabricate an agricultural robot that performs tasks such as seed sowing employing Arduino Uno, L298 motor drivers, Servo motors and Ultrasonic sensors.

Phase I involved a literature review of agricultural robotic systems, their components, and the impact of these systems on modern farming practices. The study concluded microcontroller-based robots have led to advantages in precision farming by reducing labor dependency and improving yield. Taking these into consideration, prototype design kicked off with Arduino Uno as the central controller due to its comparatively cheaper price and ease of programming. Movement was achieved through L298 motor drivers to control the movement of DC motors so it could easily maneuver along agricultural fields. In addition, servo motors were used in the mechanism of bot. The system was tested for its basic movement and actuator operations.

Phase II work will encompass the integration of additional sensors, such as ultrasonic sensors, enabling autonomous decision-making on the basis of the real-time data in the field.

Introduction

Agriculture plays a vital role in feeding the global population, and technological advancements are increasingly being integrated into farming to improve efficiency, reduce labor dependency, and enhance productivity. Traditional seed sowing methods often involve manual labor, which can be time-consuming, inconsistent, and inefficient. To address these challenges, we have designed an **Autonomous Precision Seed Sowing Robot**, a smart agricultural solution that automates the seed sowing process. This robot is equipped with **an Arduino Uno microcontroller, four DC motors, two motor drivers, an ultrasonic sensor, and a servo motor-controlled seed dispenser**, all working together to achieve accurate seed placement while navigating autonomously in the field.

The **movement of the robot** is controlled by **two L298N motor drivers**, which regulate the speed and direction of **four high-speed DC motors**. These motors provide the necessary torque to ensure smooth mobility across different terrains. To enable autonomous navigation, an **ultrasonic sensor** is used to detect obstacles in the robot's path. If an obstacle is detected, the robot intelligently alters its direction to avoid collisions. Additionally, the **servo motor** plays a crucial role in precision seeding by dispensing seeds at controlled intervals, ensuring proper spacing and reducing wastage. The power system is carefully designed with **separate power supplies for the Arduino and motor drivers**, ensuring stable performance and preventing voltage fluctuations.

The primary objective of this project is to **enhance the efficiency of agricultural operations by reducing human intervention and ensuring optimal seed distribution**. By automating the sowing process, farmers can achieve better germination rates, maximize land utilization, and reduce labor costs. Furthermore, this project has scope for future enhancements, such as integrating **moisture sensors for adaptive sowing**, **GPS navigation for precision farming**, and **AI-based decision-making for optimized field coverage**. Our Autonomous Precision Seed Sowing Robot represents a significant step toward modernizing agriculture, promoting sustainable farming practices, and making smart farming technologies more accessible to farmers worldwide.

Table 1: Summary of Relevant Academic Papers

Number	Year of Publication	Reference	Key Contribution	Important Findings
1	2018	Research and Development in Agricultural Robotics: A Perspective of Digital Farming	Reviews recent achievements in agricultural robotics, focusing on autonomous weed control, field scouting, and other digital farming applications.	Highlights the potential of agricultural robotics to revolutionize farming practices.
2	2023	Application of AI Techniques and Robotics in Agriculture: A Review	Provides a systematic review of over 150 papers examining the integration of AI and robotics in agriculture.	Emphasizes the significant role of AI in enhancing the capabilities of agricultural robots.
3	2023	Robots in Agriculture: Revolutionizing Farming Practices	Explores robotic structures in agriculture, detailing mechanisms and designs that enable precision farming.	Discusses the various types of agricultural robots and their specific applications.
4	2022	Robotics application in agriculture	Provides an overview of robotics applications in agriculture.	Highlights the potential of robotics to improve agricultural productivity and efficiency.
5	2023	Recent Advancements in Agriculture Robots: Benefits and Challenges	Consolidates diverse research on agricultural robots, discussing their applications, benefits, and challenges.	Identifies the key benefits and challenges associated with the adoption of agricultural robots.
6	2017	Technology: The Future of Agriculture	Explores the potential of technology, including robotics, to transform agriculture.	Highlights the need for technological innovation to address global food security challenges.

7	2024	Positive Public Attitudes Towards Agricultural Robots	Explores public perceptions of agricultural robots and their potential impact on farming practices.	Demonstrates that the public is generally positive about the use of agricultural robots.
8	2022	Robots and Transformations of Work in Farm: A Systematic Review of Agricultural Robotics in Sustainable Agriculture	Analyzes how the adoption of agricultural robots transforms farm work and contributes to sustainable agriculture.	Discusses the potential of agricultural robots to reduce labor costs and environmental impact.
9	2018	A Review of Agricultural Robotics: Agribots	Provides a comprehensive review of agricultural robots (agribots), discussing their design, functionality, and applications.	Offers a detailed overview of the different types of agribots and their specific uses.
10	2022	A Review of the Agricultural Robot as a Viable Device for Productive Mechanized Farming	Reviews the potential of agricultural robots to improve agricultural productivity and efficiency.	Highlights the need for further research and development to advance the capabilities of agricultural robots.

Literature Review

Several studies have focused on improving seed sowing efficiency through different mechanized approaches. Bamgboye et al. developed a manually operated okra planter, achieving a field efficiency of 71.75% and a field capacity of 0.36 ha/hr. The seed rate was 0.36 kg/hr, with a seed damage rate of 3.51%. Similarly, Gupta et al. designed and built a paddy seeder with a field capacity of 0.5 ha/hr at a speed of 0.81 m/s. Their findings indicated no damage to soaked seeds, but a 3% seed damage for pre-germinated seeds.

Ladeinde et al. conducted a comparative study on Jab planters and traditional seed planting methods, finding only minor differences in terms of manpower requirements and field capacity. Research from the University of Southern Mindanao Agricultural Research Centre introduced single and double-row planters, reducing planting time to 6–8 hours for single-row and 3–4 hours for double-row planting per hectare. Additionally, a disc-type maize seeder was developed, offering ease of use and operational comfort.

Ramesh et al. explored different innovations in seed sowing techniques, emphasizing the significance of factors such as row spacing, seed rate, and sowing depth, all of which contribute to optimal yield. The study highlighted the importance of mechanized sowing machines in enhancing agricultural efficiency. Atul et al. found that pneumatic seeders are easy to handle, making them ideal for narrower spaces while also boosting productivity. Furthermore, B. Mursec et al. compared vacuum and pressure-based pneumatic sowing machines, concluding that both offered similar performance in terms of seed-sowing capacity.

These studies collectively demonstrate the growing role of automation and mechanization in modern farming, focusing on improving efficiency, precision, and productivity while reducing labor-intensive efforts in the sowing process.

Citation: Kumar, R., Govil, A., Daga, P., Goel, S. and Dewangan, S., 2022. Design of automatic seed sowing Machine for agriculture sector. *Materials Today: Proceedings*, *63*, pp.341-346.

Summary of Literature Review

Various studies have explored different seed-sowing techniques to improve efficiency and productivity. Bamgboye et al. developed a manually operated okra planter with a field efficiency of 71.75% and a seed damage rate of 3.51%. Gupta et al. designed a paddy seeder with a field capacity of 0.5 ha/hr, showing no damage to soaked seeds but 3% damage to pre-germinated seeds.

Ladeinde et al. compared Jab planters with traditional planting methods, highlighting minor differences in manpower requirements and field capacity. The University of Southern Mindanao Agricultural Research Centre developed single and double-row planters, reducing planting time significantly. A disc-type maize seeder was also introduced, offering ease of use and operational comfort.

Ramesh et al. discussed the importance of sowing machines in achieving optimum yield, considering factors like row spacing, seed rate, and depth of sowing. Atul et al. observed that pneumatic seeders are effective for narrower spaces and improve productivity. Similarly, B. Mursec et al. compared vacuum and pressure-based pneumatic sowing machines, concluding that both offer similar seed-sowing capacity.

These studies emphasize the continuous advancements in seed-sowing technologies, highlighting the role of mechanized planting in improving efficiency, precision, and overall agricultural productivity.

Methodology

In this chapter, we describe the methodology employed in designing our Autonomous Precision Seed Sowing Robot. Our approach focuses on integrating efficient motor control, autonomous navigation, and precision seed dispensing mechanisms to achieve an optimized agricultural automation system. We have taken inspiration from existing precision farming technologies and autonomous robotics research, ensuring that our design is both cost-effective and scalable for real-world applications. This chapter outlines the specific hardware, software, and fabrication used in our project.

1. Hardware Components

Robot Platform:

- **Chassis**: The chassis of the robot is designed to be sturdy, lightweight, and capable of supporting all essential components. It provides a strong foundation for four DC motors, two L298N motor drivers, one Arduino Uno, an ultrasonic sensor, and a servo motor-controlled seed dispenser. The structure ensures stability, even weight distribution, and efficient movement across different terrains

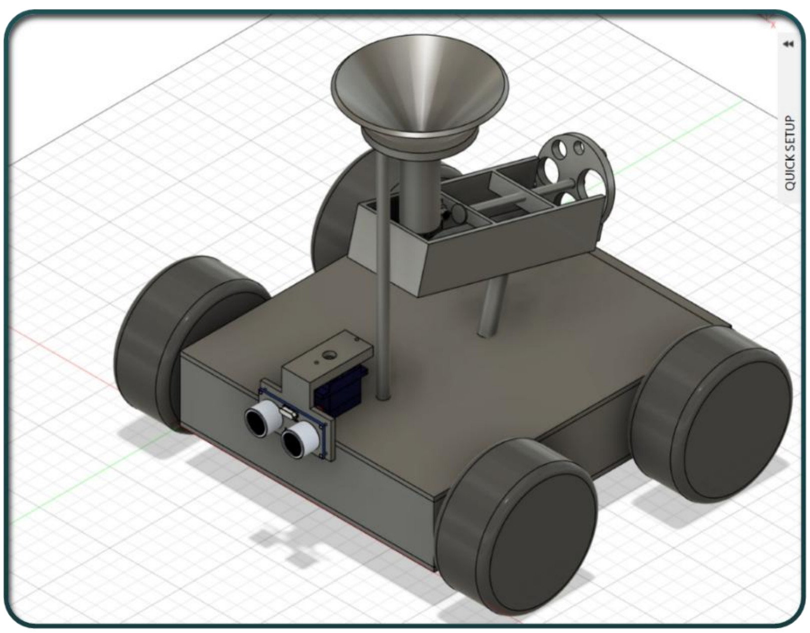


Figure 1. Design of the robot using Fusion360.

- **Actuators**:

DC Motors (Locomotion)

The robot uses four 1000 RPM DC motors to enable movement. These motors are controlled using two L298N motor drivers, allowing precise speed and direction control. They provide the necessary torque for smooth navigation across farmland.

Servo Motor (Seed Dispensing)

A SG90 servo motor is used to control the seed dispensing mechanism. It operates based on PWM signals from the Arduino, ensuring precise opening and closing of the seed outlet at regular intervals for accurate seed placement.

L298N Motor Driver (motor controlling)

The L298N motor driver is used to control the four DC motors in the robot. It allows the Arduino Uno to regulate the speed and direction of the motors using Pulse Width Modulation (PWM). The driver operates at 12V and can control two motors per module, so two L298N drivers are used for all four motors. It ensures efficient power distribution and enables the robot to navigate smoothly across the field.

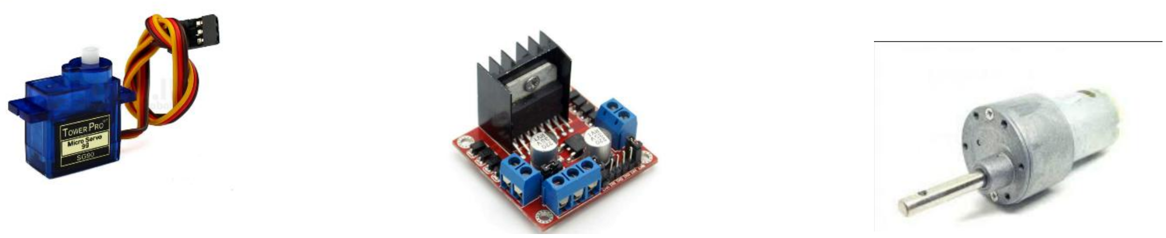


Figure 2. Actuators

Sensors:

Ultrasonic Sensor (HC-SR04):

The robot uses a HC-SR04 ultrasonic sensor for obstacle detection and autonomous navigation. It works by sending ultrasonic waves and measuring the time taken for the echo to return, allowing it to detect obstacles in real-time. The sensor helps the robot avoid collisions and adjust its path accordingly, ensuring smooth movement in the field.

Figure 3. Ultrasonic sensor (source: Karishma)

Computing Unit:

Arduino UNO:
The Arduino Uno is the main microcontroller of the robot, responsible for processing sensor data and controlling actuators. It receives input from the ultrasonic sensor, processes it, and sends signals to the motor drivers and servo motor for movement and seed dispensing. Powered by a separate battery, it ensures stable operation and precise execution of programmed instructions.

Figure 4. Arduino Uno (source: Karishma)

Power System:

- **Battery:** The battery of the robot is a Lithium Polymer (LiPo). The battery details can vary but it is sufficient in power to propel the robot into action.
- **Power Distribution:** This includes a power distribution board for regulating and dividing the power supplied from the battery to the devices so that they can be steady functioning.

Fabrication:

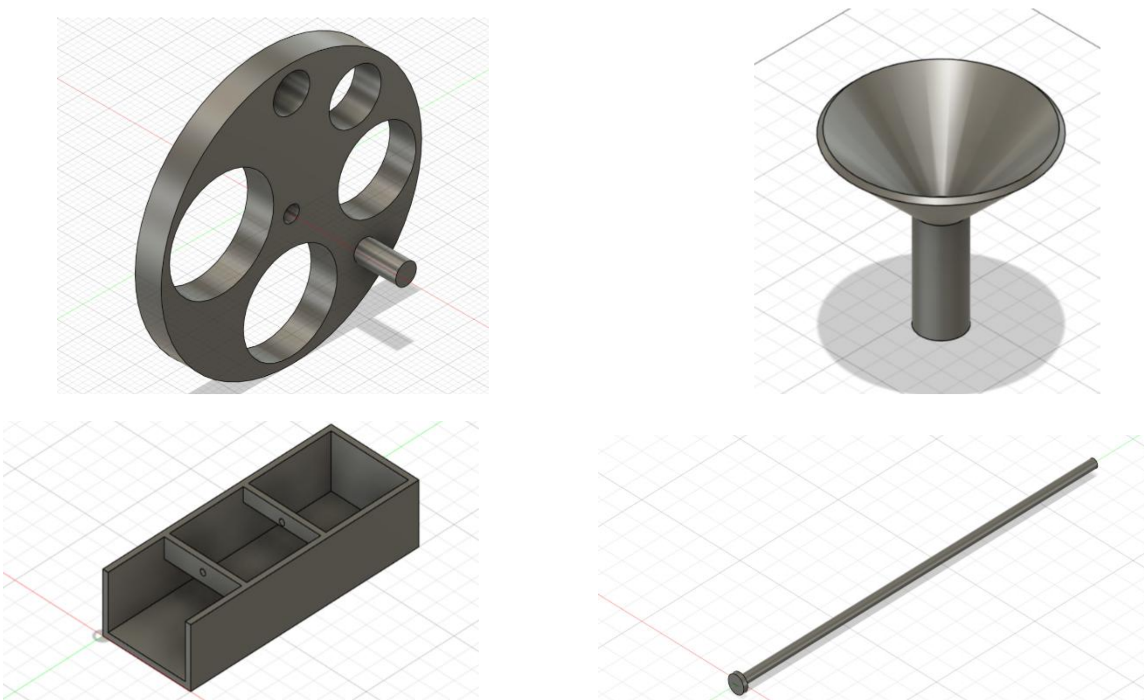


Figure 5. Seed dispensing mechanism parts

Circuit diagram:

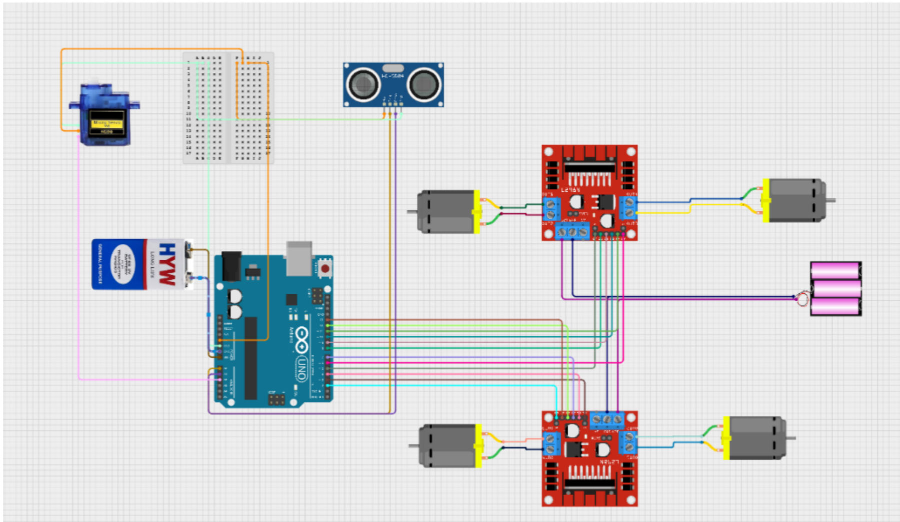


Figure 6. Circuit diagram

Table 2: Bill of materials

Components	Quantity	Unit cost	Total cost
DC Motors	4	400	1600
Wheels	4	300	1200
Arudino UNO	1	640	640
Jumper wires	1 set	190	190
L298N motor driver	2	200	400
Lipo battery	6	55	330
Servo motor	1	80	80
Ultrasonic sensor	1	70	70
3D printing	1	1600	1600
Total			6110

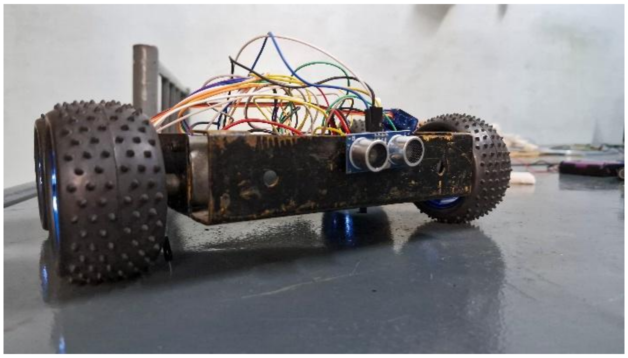
Results and Discussion:

After assembling and testing the robot, we observed that it successfully performed **autonomous navigation and precision seed sowing**. The integration of **four DC motors with L298N motor drivers** allowed smooth movement, and speed control was effectively managed through PWM signals. The **ultrasonic sensor** played a crucial role in obstacle detection, enabling the robot to change direction when necessary, ensuring uninterrupted operation in the field.

The **servo motor-driven seed dispensing mechanism** functioned as expected, releasing seeds at precise intervals. By adjusting the servo timing, we were able to control the seed flow, ensuring **uniform distribution** and reducing wastage. The **Arduino Uno** efficiently handled multiple components, processing sensor inputs and controlling motor outputs without noticeable delays.

One of the key observations was the **need for speed adjustment** in the DC motors. Initially, the high RPM caused instability, but by fine-tuning the PWM values, we achieved a more controlled movement suitable for agricultural terrain. Additionally, **separate power sources for the motor drivers and Arduino improved system stability**, preventing voltage drops and ensuring consistent performance.

Overall, the robot successfully demonstrated its ability to **navigate autonomously and plant seeds with precision**. The modular design also allows for further enhancements, such as incorporating additional sensors for better environmental adaptability. These results highlight the potential of automation in agriculture, reducing manual labor and improving planting efficiency.



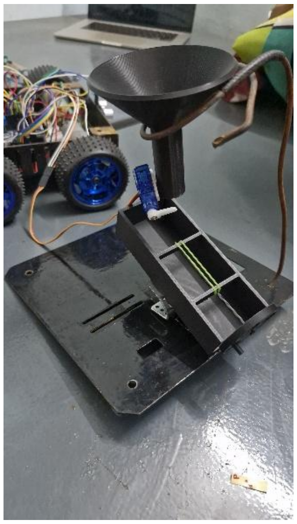


Figure 7. Results

Conclusion and Future Work

Creating an agriculture robot with Arduino Uno, servo motors, and L298 motor drivers is an inexpensive approach to automating elementary farm activities. The project implements motor control unit, sensor-based navigation, and actuation components to carry out predefined functions like seed planting. With the help of open-source hardware and software, the system remains cost-effective and easy to implement, thus making it ideal for limited resource and precision farming. The robot's success was assessed through observing its capacity to move freely throughout the farm, carry out specified tasks with a good level of accuracy, and respond to changes in the field. The evaluation results show that although the system is operational, improvements in scalability, accuracy, and flexibility would make it more effective.

To further develop the agricultural robot's functionality and work rate, the following changes and innovations are recommended for future actions:

1. **Artificial Intelligence and Machine Learning Integration** – AI-based image recognition system for monitoring crop health and identifying weeds could improve the operational decision and accuracy tremendously.
2. **Exploration of Possibilities with GPS Modules** – The implementation of GPS systems can improve self-governing navigation, allowing more efficient coverage of larger fields.
3. **Deployment of Wireless Communication and Integration within IoTs** – Improved working conditions and management of the farms will be achievable through remote monitoring and control using IoT for real-time data collection and management.
4. **Advanced Management of Power** – The running time of the robot can also be improved by solar panels and efficient battery management systems that optimize power consumption.
5. **Ability to Complete Multiple Tasks Simultaneously** – For precision farming, expanding functionalities to include automated irrigation, real-time fertilizer distribution, and soil analysis would be beneficial.
6. **Taking Sensors Primarily Accuracy** – Implementing state-of-the-art sensors would assist with more effective environmental awareness and obstacle avoidance (e.g., LiDAR, multispectral cameras).
7. **The possibility for further Development and Commercial Use** – Making the design modular for easy customization based on different farming requirements will increase marketability of the system.

The modernization and automation of farming practices, as well as the alleviation of human labor requirements, can be greatly aided by the agricultural robot thanks to these modifications. Improvements of this kind enable the robot to work independently and intelligently resulting in transformed precise farming, so that farmers may lower their expenses while raising output and sustainability in agriculture.

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