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Design and Development of a Low-Cost Bluetooth-Controlled Seed Sowing Machine

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***Abstract*—Agriculture serves as the fundamental pillar of human sustenance, yet the sector is currently grappling with the dual pressures of climate change and dwindling labor availability. Among the various stages of cultivation, seed sowing is paramount in determining final crop yields; however, traditional manual techniques remain inefficient and prone to irregular spacing. While commercial automation exists, the prohibitive cost of existing robotic sowers often excludes smallholder farmers. This study presents a cost-effective, Bluetooth-enabled robotic sowing system engineered through the lens of frugal innovation. By integrating an Arduino microcontroller with a novel Pelton wheel seed-metering mechanism and a specialized drilling component, the prototype achieved a throughput of 431 seeds per minute. This marks a substantial improvement over the manual rate of 68 seeds per minute, demonstrating the system's potential to bridge the gap between high-tech automation and rural affordability.**

***Index Terms*—Robotics, Agriculture, Automation, Arduino, Bluetooth, Seed Sowing, Frugal Innovation.**

I. Introduction

The agricultural sector is currently undergoing a revolutionary phase, shifting from manual labor to semi-automatic, fully automatic, and now robotic systems [6]. This shift is essential to address issues such as soil damage, worker shortages, and the need for precision agriculture [4]. Seed sowing is a fundamental process where accuracy directly impacts crop growth, spacing uniformity, and eventual yield [5].

Manual sowing, still prevalent in developing regions, suffers from major drawbacks including high labor requirements, inconsistent seed depth, and increased seed wastage. Advanced robotic solutions utilizing AI and GPS exist but are financially out of reach for local small-scale farmers. To bridge this gap, this project aims to design a cost-effective, efficient robotic seed sowing machine tailored for sandy soils. The proposed system allows for remote operation via an Android smartphone, making modern agricultural automation accessible and scalable.

II. Literature Review

The development of the proposed system was informed by extensive research into precision agriculture. Pedersen et al. (2006) noted that while precision technologies reshape agriculture, high upfront costs hinder adoption by smaller farms [1]. Similarly, Mouazen et al. (2007) highlighted that technical complexity remains a barrier to entry [2].

Various technical approaches have been explored in previous studies. Sadeghzadeh and Sheikhi (2013) introduced smart seed drills using sensors and microcontrollers, which improved germination rates [3]. Kumar and Singh (2018) demonstrated the utility of robotic arms for digging soil to precise depths [8]. Furthermore, Khandekar and Deshmukh (2020) validated the use of Bluetooth-controlled robots using Arduino as a viable solution for modern farming problems [7].

III. System Design and Methodology

A. System Architecture

The system integrates automated motion control with precise seed dispensing. The core logic is handled by an Arduino microcontroller, which processes commands from a Bluetooth module and drives the motors via an L298N driver.

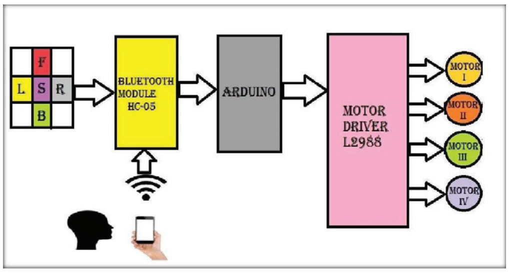

Fig. 1. Block diagram of the Bluetooth-controlled robotic system.

B. Mechanical Design

The mechanical structure was designed using SolidWorks and refined through two prototyping phases.

- **Chassis:** Constructed from lightweight plastic to ensure stability on sandy soil and reduce overall weight.
- **Pelton Wheel Mechanism:** The core sowing component is a Pelton wheel, a circular disk with bucket-like compartments along the rim. As the wheel rotates, it picks up seeds and releases them at uniform intervals.
- **Drilling Bit:** An aluminum spiral drilling bit is attached to the front of the robot. It is designed to loosen sandy soil, ensuring seeds are placed at the correct depth for germination.
- **Connectivity:** An **HC-05 Bluetooth module** facilitates wireless communication, allowing the user to control the

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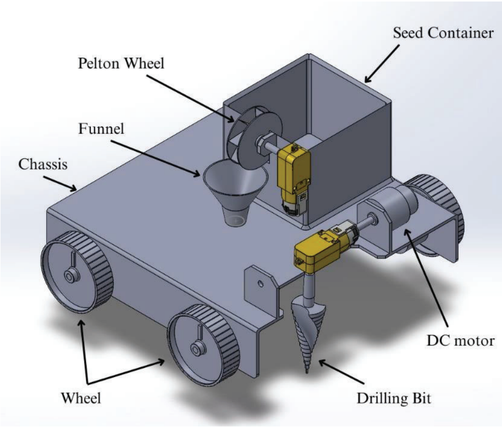

Fig. 2. Isometric CAD model of the final seed sowing robot design.

robot (forward, backward, left, right) via an Android smartphone app.

- **Actuation:** The robot is driven by **300 RPM DC motors**, providing the necessary torque for field navigation.
- **Motor Drivers: L298N motor drivers** are employed to interface the Arduino with the motors, managing direction and speed control via H-Bridge logic.
- **Power Supply:** The system is powered by a **12V Lithium-ion battery pack** configured in a 3S2P arrangement.

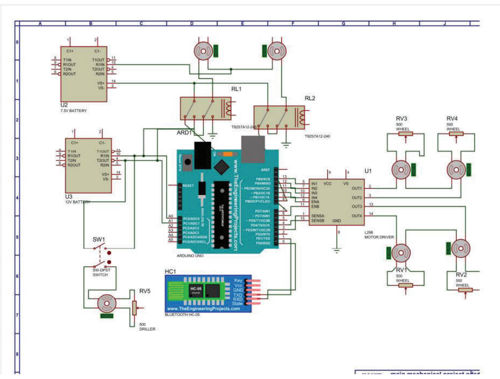

Fig. 3. Circuit diagram illustrating connections between the Arduino, Motor Drivers, and DC Motors.

C. *Design Calculations*

To ensure precise seed placement, specific calculations were performed for the Pelton wheel and robot speed.

- **Wheel Dimensions:** Diameter $d = 6.5$ cm.
- **Distance per Rotation:** $C = \pi \times d \approx 20.42$ cm.
- **Sowing Logic:** With a target seed spacing of 0.05 m and a robot speed of 0.051 m/s, the system requires approximately 1.02 seeds per second.

Based on a motor rotation of 10 RPM (0.166 RPS):

$$\text{Seeds per rotation} = \frac{1.02}{0.166} \approx 6.14 \qquad (1)$$

Therefore, the Pelton wheel was designed with **6 fins** to match the required sowing speed and spacing.

IV. Field Testing and Results

Field tests were conducted in sandy soil environments to evaluate mobility, stability, and sowing efficiency.

Fig. 4. Top view of the actual prototype during field testing.

A. *Performance Observations*

- **Mobility:** The improved chassis and drilling bit allowed the robot to maintain balance and effectively loosen soil, mitigating earlier issues of instability.
- **Seed Placement:** The redesigned Pelton wheel achieved consistent seed dropping with a success rate of approximately 85%.
- **Battery Life:** The robot operated for approximately 45 minutes under continuous load.

B. *Efficiency Comparison*

A comparative analysis between the robotic system and manual planting yielded the following results:

TABLE I
Comparison of Manual Planting vs. Robotic Machine

Metric	Manual Planting	Robotic Machine
Average Speed	$\sim$ 6.6 m/min	$\sim$ 21.6 m/min
Seeds per Minute	68	431
Seed Spacing	Inconsistent	5 cm (Average)
Planting Depth	Variable	3 cm

The data indicates that the robotic machine is significantly faster, planting seeds at a rate over **6 times higher** than manual labor while maintaining consistent depth (3 cm) and spacing (5 cm).

V. Conclusion and Future Scope

This project successfully achieved its objective of developing a low-cost, efficient, robotic seed sowing machine suitable for small-scale farmers. By utilizing frugal innovation, the system overcomes the cost barriers of advanced agricultural robotics. The integration of a drilling bit and a synchronized Pelton wheel ensured effective sowing in sandy soil conditions, reducing human labor and increasing productivity.

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Future iterations could include:

- **Autonomous Navigation:** Integration of GPS modules and obstacle detection sensors.
- **Advanced Sensing:** Incorporation of soil moisture sensors and AI for real-time adaptability.
- **IoT Integration:** Development of GSM or IoT capabilities for remote monitoring and data analytics.

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