Design and Fabrication of Automatic Farm-Mate

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Abstract— The rapid advancement of technology has significantly transformed various sectors, including agriculture. The IoT-based Seed Sowing and Fertilizer Machine is a solution designed to enhance the efficiency, accuracy, and sustainability of agricultural practices by automating the processes of seed sowing and fertilizer application. This system leverages the power of the Internet of Things (IoT) to create a more intelligent, data-driven approach to farming. By integrating sensors, microcontrollers, actuators, and wireless communication, this machine can monitor environmental conditions in real-time and adjust operations accordingly. It uses soil moisture, temperature, and fertility data to optimize the seed planting and fertilizer dispensing processes, ensuring precise and consistent application. Moreover, the system allows for remote monitoring and control, providing farmers with greater flexibility and convenience.

This IoT-based machine aims to overcome challenges faced by traditional farming techniques, such as manual labor shortages, resource wastage, and low operational efficiency. By automating critical tasks, farmers can reduce their reliance on human labor, minimize input costs, and improve crop yields. The real-time monitoring capabilities not only improve efficiency but also contribute to sustainable farming by minimizing the excessive use of fertilizers and seeds. This paper discusses the design and fabrication of the IoT-based seed sowing and fertilizer machine, highlighting its components, working mechanism, and potential impact on modern agriculture. The system's implementation and the benefits it offers to farmers demonstrate its promise in revolutionizing the agricultural industry through precision and automation.

Keywords: Internet of Things, Seed Sowing, Fertilizer Application, Agricultural Automation, Smart Farming

I. INTRODUCTION

Agriculture is the backbone of the global food system, providing sustenance for billions of people around the world. However, traditional farming practices often struggle with inefficiencies, labor shortages, and resource wastage, leading to suboptimal crop yields and increased costs. Tasks like seed sowing and fertilizer application, which are essential to successful farming, are particularly labor-intensive and require significant time and skill. As the global population continues to rise, the need for more efficient, resource-conserving agricultural methods becomes more urgent. In response, technological advancements, particularly the integration of Internet of Things (IoT), offer a transformative opportunity for modern farming.

The IoT-based Seed Sowing and Fertilizer Machine is designed to address these challenges by automating the critical processes of planting seeds and applying fertilizers. Through the use of sensors that monitor soil conditions such as moisture levels, temperature, and nutrient content, this system can optimize the placement of seeds and the distribution of fertilizers. IoT technology enables real-time data collection and remote monitoring, allowing farmers to make data-driven decisions and manage their operations more effectively. This automation not only reduces the need for manual labor but also minimizes the overuse of seeds and fertilizers, promoting more sustainable farming practices. By improving the efficiency of essential farming operations, this IoT-based system promises to increase productivity, reduce costs, and pave the way for a smarter, more sustainable agricultural future.

II. LITERATURE REVIEW

Automatic seed sowing technology plays a critical role in modern agriculture by improving planting efficiency, reducing labor costs, and ensuring uniform seed distribution. This literature review provides a summary of the key findings from various papers on the design, development, and improvement of automatic seed sowing machines.

[1] Astanakulov's study presents an adaptation mechanism for a sowing apparatus designed for soybean seeds with minimal damage. The study emphasizes the importance of preserving seed integrity during sowing to enhance crop yields. The focus on reducing damage to seeds during sowing processes is a significant advancement in precision agriculture. The paper discusses how mechanical adjustments in the seed sowing apparatus can improve the survival rate of soybean seeds and, consequently, the efficiency of farming operations.

[2] Dhande et al. highlight the design and development of an automatic seed sowing machine. Their approach aims to reduce manual labor by automating the sowing process. The paper describes various components of the machine, including the automation system, which can detect soil conditions and adjust sowing depth accordingly. The authors argue that automation in the sowing process will enhance agricultural productivity and reduce the need for human intervention, thereby making farming more efficient.[3] Kumar et al. focus on the design of an automatic seed sowing machine intended for the agricultural sector. Their machine utilizes sensors and automated control systems to ensure precise seed placement and spacing. This paper stresses the importance of accurate seed sowing for optimizing crop yields. The study also discusses the integration of technology such as remote control and IoT to improve the machine's operational capabilities and ease of use in diverse agricultural environments.[4] Boopathiraja's work explores the design and fabrication of a solar-powered seed sowing machine, which can be remotely controlled. This paper emphasizes sustainability and energy efficiency by integrating solar power into agricultural machinery. The use of renewable energy in agricultural machinery is particularly relevant in reducing dependence on conventional energy sources and decreasing the environmental impact of farming operations.[5] Beljaev's research investigates the effect of various sowing techniques on the agroecological parameters of cereal crops. This paper provides an in-depth analysis of how different sowing methods, including automatic machines, impact crop health, yield, and environmental sustainability. By comparing traditional sowing techniques to mechanized ones, the study offers valuable insights into optimizing sowing practices for different types of crops.

[6] Bhagya Sri et al. introduced an IoT-based agricultural robot that can perform multiple tasks such as ploughing, seeding, and sprinkling. This paper demonstrates how the integration of IoT technology in agriculture can enable remote monitoring and operation of seed sowing machines, increasing the level of automation and precision in farming practices. The IoT capabilities allow farmers to control and track the machine's activities from a distance, contributing to more efficient and effective farming operations.[7] Sangole et al. developed a semi-automatic seed sowing robot. This system integrates sensors and actuators for basic automation, although it requires some human intervention for full operation. The paper emphasizes the potential of semi-automatic systems in small to medium-scale farms where complete automation may not be economically viable. The machine offers a balance between automation and manual intervention, providing a flexible solution for diverse farming environments.

The development of automatic seed sowing machines has led to substantial improvements in agricultural productivity. By automating the seed sowing process, these machines reduce labor costs, improve planting accuracy, and ensure uniform seed distribution. Technological advancements, such as IoT integration, solar power, and sensor-based systems, have further enhanced the efficiency and sustainability of these machines. As the agricultural industry continues to embrace automation, future research will likely focus on refining these systems for even greater precision, sustainability, and adaptability to various farming environment.

COMPONENTS USED

The automatic seed sower system is designed to facilitate precision sowing in agricultural fields. This system uses various components, each playing a specific role in ensuring the functionality, efficiency, and accuracy of the seed-sowing process. Below are the key components integrated into this system:

- ESP32 Microcontroller
- Motor Drive

- Wiper Motor
- Load Sensor
- Temperature Sensor

ESP32 Microcontroller:

The ESP32 is a powerful, low-cost microcontroller that serves as the central control unit in the automatic seed sower. It is equipped with Wi-Fi and Bluetooth capabilities, making it ideal for remote monitoring and control of the seed-sowing process. The ESP32 processes sensor data and sends commands to other components in the system, such as the motor driver and sensors. Dual-core processor for efficient multitasking. Built-in Wi-Fi and Bluetooth for wireless communication. Low power consumption, suitable for battery-operated applications. Multiple GPIO pins for interfacing with various sensors and actuators.

The ESP32 ensures that the system is intelligent, allowing for easy integration of IoT-based functionalities like real-time monitoring and adjustments through a smartphone or computer.

Motor Driver(L298N):

The motor driver is a crucial component that acts as an interface between the microcontroller (ESP32) and the wiper motor. It regulates the voltage and current to the motor, ensuring smooth and controlled operation. The motor driver enables the precise movement of the seed-sowing mechanism by controlling the direction, speed, and force applied to the wiper motor.Controls the motor's speed and direction using PWM (Pulse Width Modulation).Protects the system from overcurrent, overheating, and reverse polarity.Provides efficient power conversion and distribution.Supports both DC motors and stepper motors, allowing for flexible designs.

The motor driver ensures that the system's movement is reliable and consistent, which is critical for uniform seed distribution.

Gear Motor:

The gear motor is responsible for the mechanical movement of the seed-sowing mechanism. It drives the mechanism that dispenses seeds at regular

intervals. The motor's speed and motion are controlled by the motor driver based on the signals received from the ESP32, ensuring that the seeds are sown accurately in the soil.Reliable, high-torque DC motor.Compact design suitable for agricultural applications.Adjustable speed and rotation based on the task requirements.

The gear motor's role is to mimic the movement of a traditional seed-sowing machine but with enhanced precision, reducing manual labor and optimizing seed placement.

Load Sensor:

The load sensor is integrated into the seed dispenser to measure the amount of seeds dispensed by the system. By detecting changes in weight as seeds are being distributed, the load sensor provides real-time feedback to the microcontroller. This data is crucial for ensuring that the proper amount of seeds are sown at each interval, preventing wastage or insufficient sowing.High accuracy in measuring small changes in weight.Provides real-time data for automatic adjustments to the sowing process.Can be easily interfaced with the ESP32 using analog or digital signals.

The load sensor ensures that the seed sower works with high efficiency, helping in precise seed distribution, which directly impacts crop yield and resource usage.

Thus, the integration of these components—ESP32 microcontroller, motor driver, wiper motor, load sensor, and temperature sensor—forms the backbone of the automatic seed sower system. Each component has been carefully selected and optimized to ensure that the system is efficient, reliable, and accurate in performing its task. The system not only automates the seed sowing process but also provides the necessary feedback for real-time adjustments, making it an innovative solution for modern agricultural practices.

The automatic seed sower system consists of several key components that work together to ensure efficient and precise seed sowing. At the core of the system is the ESP32 microcontroller, which acts as the central control unit. This microcontroller is equipped with Wi-Fi and Bluetooth capabilities, allowing for wireless communication and remote monitoring. Itprocesses data from various sensors and controls the operation of other components, ensuring seamless functionality

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III. CALCUL;ATION

DESIGN AND FABRICATION OF AUTOMATIC FARMATE:

The volume of a pyramid shaped hopper: V=1/3×L×W× H
$V=0.00267\ m^3$

Mass of Seeds:

The mass can be calculated as:

m=ρ×V m=1.6kg

Battery calculation:

Total Power Consumption:

DC Gear Motor (4 units) =38.4 W DC Motor (1 unit) =18 W
ESP32 Microcontroller=1W Relays (6 units) =5.76 W Pump (1 unit) =6W
DHT11 Sensor=0.025 W

Total Power Consumption =69.185 W

Rounding off to 69.2 W for practical calculation. Battery Capacity Requirement
Battery Capacity (Ah)=(Ptotal×Runtime)/V Battery Capacity==5.77 Ah
By considering the above requirement we choose 12 v and 7Ah Lead acid battery.

Battery Weight Calculation Formula: Lead-acid battery weight can be estimated using the formula:

Weight =Energy Density/Capacity The battery capacity in watt-hours is:
Capacity (Wh)=Voltage (V)×Capacity (Ah) For a 12V, 7Ah battery:
Capacity (Wh)=12×7=84 Wh

Typical energy density for a lead-acid battery is around 30-40 Wh/kg. We'll use an average of 35 Wh/kg.

Weight (kg)=84 Wh/35 Wh/kg=2.4 kg Weight calculation:
Electrical Components Weight Total weight of gear motors=2 kg DC Motor Weight: 0.8 kg Battery Weight: 2.4 kg
Pump Weight: 0.4 kg

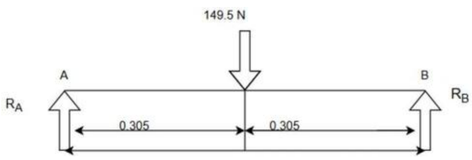
ESP32 Microcontroller Weight: 0.02 kg Relays Weight =0.12 kg
DHT11 Sensor Weight: 0.01 kg Mechanical Components Weight Hopper (including seeds):

- Hopper weigh== 0.39 kg
- Seed mass: 1.6 kg

Total hopper weight=1.99 kg

≈2kg Water Tank (filled) =10.5 kg
Total weight frame =18.25kg
≈18.3kg Length of the frame=0.61m

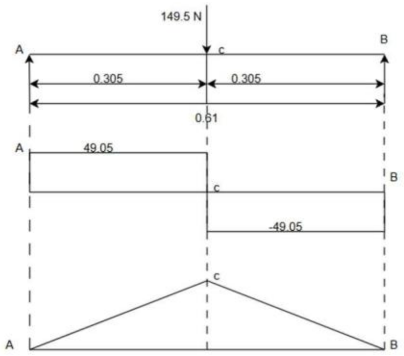
Width of the frame=0.45m W=179.5N



ISSN: 2583-6129
DOI:10.55041/ISJEM03430

$R_A = R_B = W/2$

=89.75N



I/M=y/σ M=(W×L)/4
=27360.75Nmm

Moment of Inertia (I) for a Hollow Square Beam:

$I = (b^4 - (b-2t)^4)/12$

y=b/2 Thus,
$27360.75/((b^4-(b-2t)^4)/12) = 250X10^6/(b/2)$

t=1.76mm

≈2mm Volume=Length×Width×Thickness Volume=549×10^3 mm^3 Weight=Volume×Density Weigh=4.31 kg
Total Weight=22.61kg

≈23kg Wheel Selection
Load per Wheel Calculation:

Since the machine has 4 wheels, the load on each wheel is calculated as:

Load per wheel=Total Weight/4

=5.75 kg

For safety, we select a wheel that can handle 6 kg each.

Rolling Resistance (F_r):

$F_r = \mu$ x W

=0.02 x 228.18

=4.56 N

Gravitational Force(F_g) F_g=W x Sin(5°)
=23.26x 9.81x0.0872

=19.91 N

Total traction force (F_t): $F_t = F_g + F_r$
=4.56+19.91

=24.47 N

Traction force(T_t) $T_t = F_t x r_w$
=24.47 x 0.0762

=1.86Nm

Torque per motor:

$T_m = T_t/4$

=1.86/4

=0.465Nm

Selection of controller:

To select the appropriate microcontroller for the machine, we need to consider the following factors:

Input and Output Requirements:

Number of Motors:

- 4 × DC Gear Motors (12V, 0.8A)
- 1 × DC Motor (12V, 1.5A)

Sensors:

- 1 × DHT11 Sensor (Temperature and Humidity) Actuators:
- 6 × Relays (12V, 0.08A each)
- 1 × Pump (12V, 0.5A)

Communication:

- Wi-Fi/Bluetooth for IoT connectivity Parameters to Consider:
Number of GPIO Pins:

- 4 pins for DC gear motors (using motor driver/relay)
- 1 pin for DC motor
- 6 pins for relays
- 1 pin for DHT11 sensor
- Total GPIO Pins Required: 12
Communication Protocols:
- Wi-Fi: To connect to IoT platforms
- Bluetooth: For local communication and control

Power Requirements:

- Operating Voltage: 5V/3.3V

ISSN: 2583-6129
DOI:10.55041/ISJEM03430

- Low Power Consumption Processing Power and Memory:
- Adequate for real-time motor control and sensor data processing
- Enough flash memory to store the program Recommended Microcontroller: ESP32 Reasons for Choosing ESP32:

Sufficient GPIO Pins:

- ESP32 typically has 30-36 GPIO pins, enough for all components.

Built-in Wi-Fi and Bluetooth:

- Supports IoT connectivity directly without external modules.

Operating Voltage:

- Works at 3.3V, but compatible with 5V logic via level shifters.

High Processing Speed:

- Dual-core Tensilica CPU, operating at 240 MHz.

Memory:

- 520 KB SRAM and 4 MB flash (varies with model).

Low Power Consumption:

- Ideal for battery-powered applications.

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