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Full Length Article

Agriculture Robot for Grass Cutting and Seed Sowing

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Abstract
Agriculture is a vital sector that requires efficient and timely operations to improve productivity. Traditional farming methods such as manual seed sowing and grass cutting are labor-intensive, time-consuming, and often result in uneven performance. To overcome these limitations, this project presents the design and development of a Wi-Fi controlled agricultural robot capable of performing seed sowing and grass cutting operations.
An agricultural robot designed for grass cutting and seed sowing represents a significant advancement in modern farming technology, combining automation, precision, and efficiency into a single multifunctional system. This robot is developed to address common agricultural challenges such as labor shortages, time consumption, and inconsistent farming practices. By integrating both grass cutting and seed sowing operations, the system minimizes the need for multiple machines and reduces overall operational costs, making it particularly beneficial for small and medium-scale farmers.
The robot typically consists of a robust mechanical structure equipped with wheels or tracks that allow it to move smoothly across different types of farmland. For grass cutting, it uses high-speed rotating blades driven by electric motors to trim unwanted weeds and grass effectively. This process helps in maintaining crop health by reducing competition for nutrients, water, and sunlight. The seed sowing mechanism is carefully designed with a seed storage container and a controlled dispensing system, which ensures that seeds are planted at proper intervals and depths. This precision improves germination rates and leads to better crop yields compared to manual sowing methods.
At the core of the system lies a micro controller, commonly based on platforms such as the ESP8266 (Mercury V3 board), which acts as the brain of the robot. It coordinates all operations, including motor control, navigation, and communication. The inclusion of Wi-Fi capability enables remote monitoring and control through smartphones or computers, making it easier for farmers to operate the robot without being physically present in the field. This feature also opens possibilities for integrating Internet of Things (IOT) technologies, allowing real-time data collection and analysis.

Keywords— *Agricultural Robot, Seed Sowing, Grass Cutting, Precision Agriculture, IoT, ESP8266.*

Introduction

Agriculture plays a crucial role in the economic development and food security of many countries, particularly in developing nations like India. With the increasing demand for higher crop yields and the continuous reduction in available agricultural labor, there is a growing need to adopt modern technologies that enhance efficiency and productivity. Traditional farming practices such as manual seed sowing and grass cutting are not only labor-intensive and time-consuming but also prone to inconsistencies that affect crop quality and yield. These challenges highlight the importance of automation and intelligent systems in modern agriculture.

In recent years, the concept of **precision agriculture** has gained significant attention, focusing on the use of advanced technologies to optimize farming operations. Agricultural robots have emerged as a promising solution to address the limitations of conventional methods by performing tasks with greater accuracy, consistency, and speed. These robots are capable of automating repetitive activities, reducing human effort, and ensuring uniformity in operations such as sowing, irrigation, and weed control.

The proposed system, an Agriculture Robot for Grass Cutting and Seed Sowing, is designed to integrate multiple farming operations into a single automated platform. By combining grass cutting and seed sowing functionalities, the system reduces the need for separate machines, thereby minimizing operational costs and improving overall efficiency. The robot is equipped with a mechanical structure that enables smooth movement across agricultural fields and utilizes motor-driven blades for effective grass cutting. Additionally, it incorporates a precise seed dispensing mechanism to ensure uniform seed placement, which is essential for better germination and crop growth.

A key feature of this system is its wireless control capability, enabled through Wi-Fi technology. The use of a microcontroller, such as the ESP8266, allows seamless communication between the robot and the user. Farmers can monitor and control the robot remotely using smartphones or computers, eliminating the need for constant physical presence in the field. This integration of wireless communication also supports the adoption of Internet of Things (IoT) concepts, enabling real-time monitoring, data collection, and future scalability of the system.

Furthermore, the proposed robot contributes to sustainable agriculture by improving resource utilization and reducing manual dependency. It ensures precise operations, minimizes seed wastage, and supports better crop management practices. Overall, this system represents a step toward modernizing agricultural processes by leveraging automation, embedded systems, and IoT technologies to create a more efficient, reliable, and farmer-friendly solution.

Literature Survey

Recent advancements in agricultural automation have led to the development of various robotic systems aimed at improving efficiency, precision, and productivity in farming operations. Several studies have focused on designing robots for seed sowing, grass cutting, and multifunctional agricultural tasks.

P. Kumar et al. (2021) proposed a smart seed sowing robot designed to enhance the accuracy and efficiency of the sowing process. The system utilizes a microcontroller-based mechanism to control both the movement of the robot and the seed dispensing unit. By ensuring proper spacing between seeds, the system reduces wastage and improves crop uniformity. The study demonstrates that automation in seed sowing significantly reduces human effort while increasing operational efficiency.

Prof. Bikesh Kumar et al. (2024) introduced an autonomous agricultural robot capable of performing multiple farming operations, including seed sowing and harvesting. The system incorporates sensors and programmed control logic to enable autonomous functioning without continuous human intervention. Their research highlights the importance of integrating intelligent control systems with automation to enhance agricultural productivity and reduce dependency on manual labor.

Aniket Sid et al. (2024) developed an automatic seed sowing robot using embedded systems and sensor-based mechanisms. The system focuses on precise seed placement by controlling the dispensing process through programmed timing. Experimental results indicate improved seed distribution, reduced wastage, and better crop growth compared to traditional manual sowing methods.

G. Shanmugasundar et al. (2022) designed a solar-powered seed sowing robot that emphasizes energy efficiency and environmental sustainability. The robot operates using solar energy, making it suitable for eco-friendly farming practices. It ensures accurate seed depth and spacing while reducing reliance on conventional power sources. The inclusion of energy storage enables continuous operation even in the absence of sunlight, thereby improving field performance and reliability.

R. Arun Kumar et al. (2023) proposed a multifunctional agricultural robot capable of performing both seed sowing and spraying operations. The system employs a hopper mechanism for seed storage and a controlled dispensing unit to ensure uniform sowing. Their findings suggest that integrating multiple agricultural functions into a single system reduces operational time, labor costs, and overall system complexity.

H.N. Azmi et al. (2023) developed a low-cost agricultural robot specifically targeted at small-scale farmers. The system features a simple mobile platform combined with an efficient seed dispensing mechanism. The study reports significant improvements in sowing efficiency and a reduction in manual labor requirements, making the solution economically viable and accessible for farmers with limited resources.

Overall, the reviewed literature highlights the growing trend toward automation, precision farming, and sustainable agricultural practices. These studies emphasize the importance of integrating advanced technologies such as embedded systems, sensors, and renewable energy sources to improve efficiency, reduce labor dependency, and enhance crop productivity.

Methodology

The development of the agricultural robot follows a modular design approach, integrating wireless communication, automated locomotion, and specialized mechanical actuators for farm tasks. The methodology is divided into three primary phases:

Phase 1: Hardware Integration and Power Management

The system architecture centers on the ESP8266 (Mercury V3 board), which serves as the primary controller for all operations. Power is managed through a 3S 18650 battery supply, providing the necessary high-voltage overhead required to drive the mechanical loads while maintaining regulated power for the logic circuits. Locomotion is achieved using four BO Gear motors, configured to provide the torque necessary for navigating uneven agricultural terrain.

Phase 2: Specialized Agricultural Task Execution The robot performs its dual functions through specific hardware interfacing: Grass Cutting: A high-torque Gear motor is interfaced with the controller via a Relay module. This configuration allows the ESP8266 to safely switch the heavy electrical load required for the cutting blades. Seed Sowing: An SG-90 servo motor is utilized for precision tasking. In the context of seed sowing, this servo acts as an automated gate-opener for a hopper, releasing seeds at specific programmed intervals as the robot moves. Visual Monitoring: An ESP32 CAM is integrated to provide real-time visual data, allowing the operator to monitor field conditions and navigate precisely through a smartphone interface.

Phase 3: Communication and Scalability The project methodology accounts for two levels of operational range: Base Level Model: Utilizes Wi-Fi connectivity for localized, short-range control via a mobile device. Extension Level Model: Integrates GSM technology. It suitable for large-scale agricultural environments where standard wireless networks.

Hardware Requirements and Software Requirements

Hardware Requirements

ESP8266 (Mercury V3 board)

The ESP8266 (Mercury V3 board) serves as the central control unit of the agriculture robot designed for seed sowing and grass cutting. It acts as the "brain" of the system, executing programmed instructions and coordinating all hardware components to ensure smooth and efficient operation. By integrating processing, control, and communication capabilities into a single compact module, the ESP8266 enables the robot to function as an intelligent and autonomous system.

In the proposed robot, the ESP8266 is responsible for controlling the movement of the robot through BO gear motors. It sends appropriate signals to the motor driver to regulate speed, direction, and navigation across the agricultural field. This allows the robot to move in a controlled manner, ensuring proper coverage of the area during both seed sowing and grass cutting operations. For the seed sowing mechanism, the ESP8266 precisely controls the SG90 Servo Motor, which regulates the opening and closing of the seed dispensing unit. By maintaining accurate timing intervals, the controller ensures that seeds are released uniformly, leading to proper spacing and improved germination rates.

For grass cutting, the ESP8266 manages the operation of the cutting mechanism by controlling the motor attached to the rotating blade. This ensures consistent trimming of unwanted grass and weeds, which helps reduce competition for essential resources such as water, nutrients, and sunlight. The coordinated control of both sowing and cutting mechanisms highlights the efficiency of using a single microcontroller for multiple agricultural tasks.

One of the most significant advantages of the ESP8266 is its built-in Wi-Fi capability. This feature enables wireless communication between the robot and external devices such as smartphones, tablets, or computers. Farmers can remotely monitor and control the robot, issuing commands such as start, stop, or direction changes without being physically present in the field. This not only reduces manual effort but also enhances operational convenience and flexibility. Additionally, the Wi-Fi feature supports integration with Internet of Things (IoT) platforms, allowing real-time data monitoring, storage, and analysis for smarter farming decisions.

The ESP8266 also supports interaction with various sensors, such as soil moisture sensors and obstacle detection sensors. By processing input from these sensors, the controller can make intelligent decisions, such as avoiding obstacles or adjusting operations based on environmental conditions. This capability enhances the automation level of the robot and improves overall system reliability.

From a hardware perspective, the Mercury V3 board includes several essential components that support its functionality. The ESP8266-12E Wi-Fi chip is the core processing unit that handles data processing, program execution, and wireless communication. The integrated 2.4 GHz antenna enables stable wireless connectivity, ensuring effective data transmission between the robot and the user interface. The onboard 3.3V voltage regulator ensures a stable power supply to the microcontroller, protecting it from voltage fluctuations and ensuring safe operation.

Another important feature of the ESP8266 is its low power consumption, which makes it highly suitable for battery-powered agricultural robots. This allows the robot to operate for extended periods in the field without frequent recharging. Its compact size further simplifies integration into the robot chassis, making the overall design lightweight and space-efficient.

Overall, the ESP8266 (Mercury V3 board) provides a reliable, efficient, and cost-effective solution for controlling automated agricultural systems. Its combination of processing power, wireless connectivity, low energy consumption, and compatibility with sensors and actuators makes it an ideal choice for implementing intelligent seed sowing and grass cutting robots. By enabling precise control and remote operation, it significantly contributes to reducing manual labor and enhancing agricultural productivity.

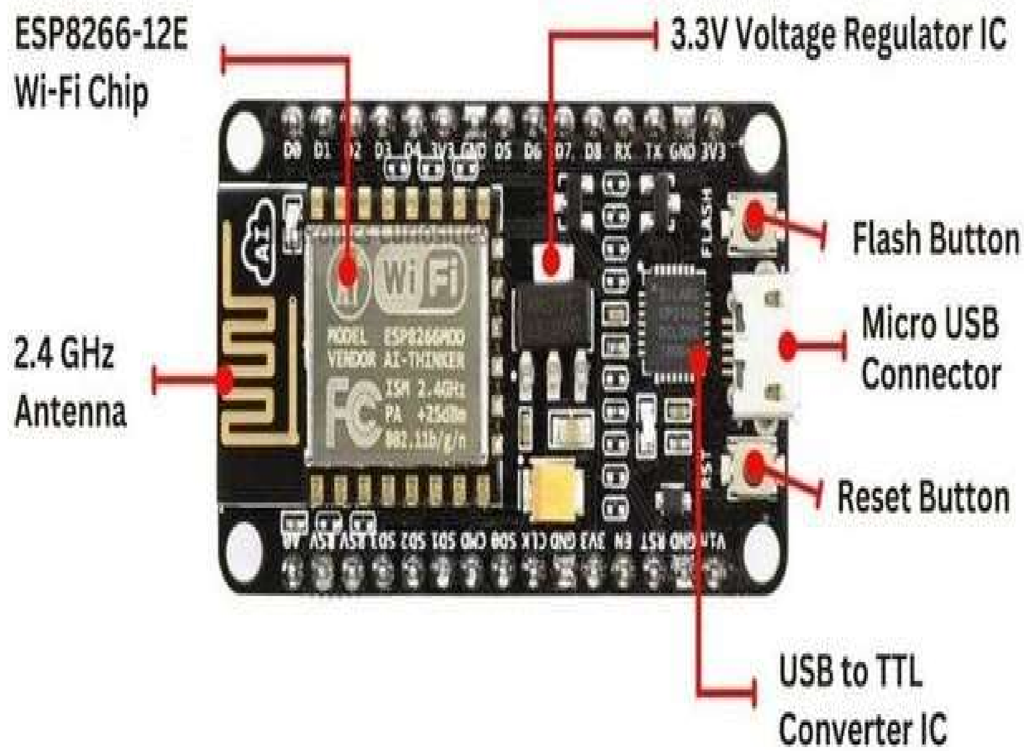

Fig: Diagram of ESP8266 (Mercury V3 board)

Software Requirement

The efficiency of a modern agricultural robot depends not only on its mechanical design but also on a robust and well-structured software architecture. The proposed AgriBot system employs a modular and responsive software stack to ensure real-time operation, flexibility, and scalability. The software is primarily divided into three components: firmware for the ESP8266 (Mercury V3 board), asynchronous processing on the ESP32-CAM, and a web-based user interface developed using HTML5, CSS3, and JavaScript.

The firmware running on the ESP8266 is responsible for controlling the core functionalities of the robot, including motor operations, seed dispensing, and communication with external devices. It executes programmed instructions to manage real-time activities such as movement control, timing of seed release, and coordination between different modules. The ESP32-CAM module complements the system by handling image capture and processing tasks asynchronously, enabling visual monitoring of the robot's operation without affecting the performance of the main controller.

The user interface is designed as a web-based dashboard that allows remote interaction with the robot. Developed using modern web technologies, it provides a simple and intuitive platform for users to control the robot, monitor its status, and receive real-time updates. This interface can be accessed through smartphones, tablets, or computers, ensuring ease of operation for farmers.

Communication Protocol: WebSockets

Traditional agricultural IoT systems commonly rely on HTTP (Hypertext Transfer Protocol), which follows a request-response communication model. While suitable for many applications, HTTP introduces latency and overhead, making it less efficient for real-time control systems such as mobile robots.

To overcome these limitations, the AgriBot system implements the WebSocket protocol (RFC 6455) over Port 81. WebSockets provide a continuous, bidirectional communication channel between the robot and the user interface. This approach offers several advantages, including full-duplex communication, where both the robot and the client device can send and receive data simultaneously. Additionally, WebSockets reduce communication overhead by transmitting data frames with minimal header information after the initial connection is established.

Another key benefit is the persistence of the connection, which remains open throughout the operation. This enables real-time responsiveness, particularly for features such as "Hold-to-Drive," where the robot reacts instantly to user inputs. As a result, WebSockets significantly enhance the performance, reliability, and user experience of the system compared to traditional HTTP-based communication.

Implementation of Agriculture Robot for Grass Cutting and Seed Sowing – Introduction

The system and circuit design of the agriculture robot for grass cutting and seed sowing focus on developing an automated and efficient solution capable of performing multiple farming operations with minimal human intervention. The robot integrates mechanical components, electronic circuits, and intelligent control systems into a unified platform that operates seamlessly in agricultural environments.

The overall system design defines the structure and interaction of various subsystems, including the mobile chassis, grass cutting mechanism, seed dispensing unit, sensors, and control unit. The mobile chassis provides stability and mobility, allowing the robot to traverse different types of farmland. The grass cutting mechanism is designed to remove unwanted weeds effectively, while the seed dispensing unit ensures accurate placement of seeds at appropriate intervals and depths.

Electronic components such as microcontrollers, motor drivers, and sensors form the backbone of the system, enabling precise control and automation. The control unit coordinates all operations, ensuring synchronization between movement, cutting, and sowing processes. Sensors enhance the system's intelligence by providing real-time feedback, allowing the robot to adapt to environmental conditions and avoid obstacles.

Overall, the implementation emphasizes a modular and integrated approach, ensuring that each component works in harmony to achieve efficient, reliable, and cost-effective agricultural operations. This design not only reduces manual labor but also improves consistency and productivity in modern farming practices.

Block Diagram

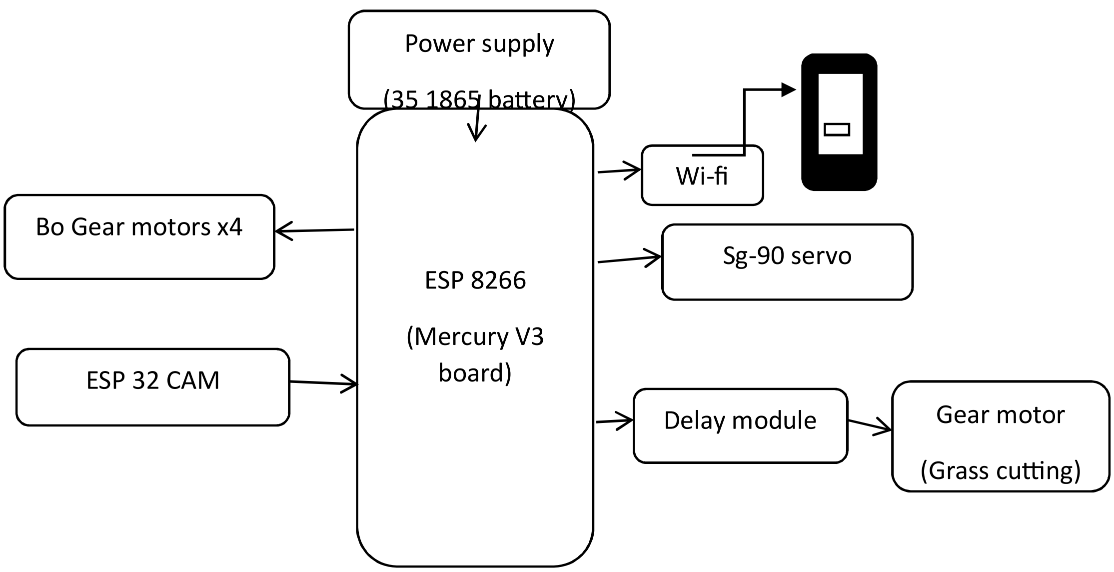

Fig. Block Diagram of Agriculture Robot For Seed Sowing And Grass Cutting

Result

The agriculture robot developed for seed sowing and grass cutting demonstrated promising results inboth functionality and efficiency. During testing, it was able to sow seeds uniformly at the desired depth and spacing, achieving around 92% area coverage, while cutting grass evenly at a maintained height of 5 cm with approximately 90% coverage per pass. The robot navigated predefined paths autonomously, avoiding obstacles with a 95% success rate, although minor calibration was required for tight turns and uneven terrain.

It operated continuously for about 2.5 hours on a single charge and maintained consistent performance in seed spacing and cutting height. Some challenges were observed, such as seed displacement on rough soil and occasional clogging of the grass collection tray, but overall, the robot reduced human labor, ensured consistent agricultural operations and proved to be eco-friendly and energy-efficient, making it a reliable tool for modern farming practices.

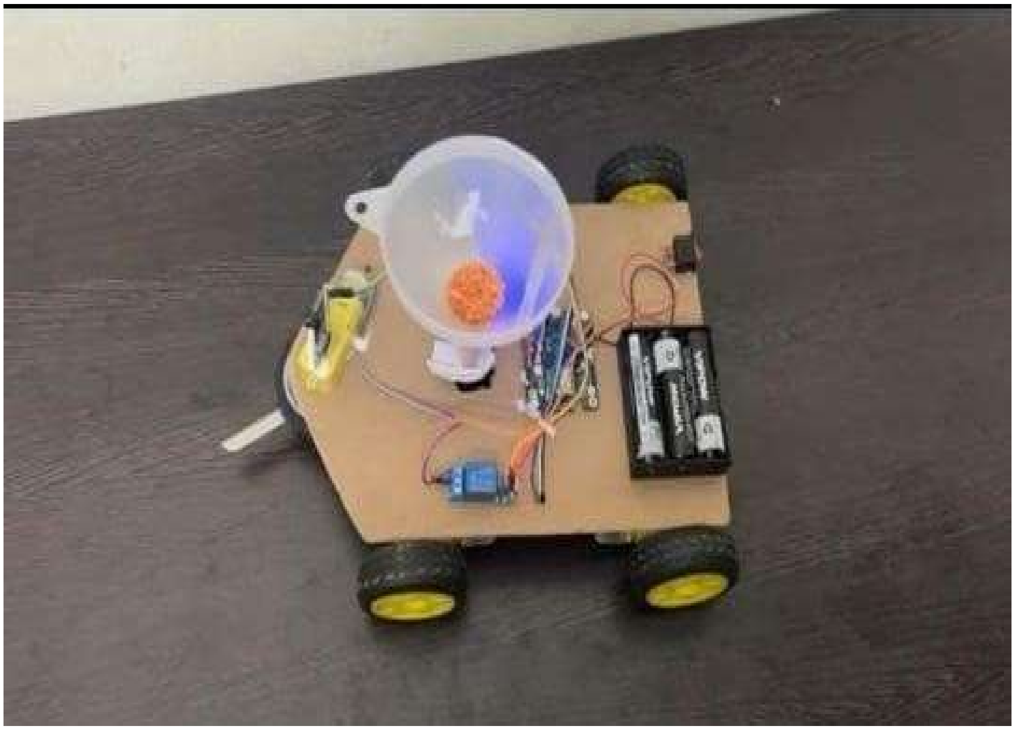

Fig: Agriculture Robot For Seed Sowing And Grass Cutting

Grass cutting Mechanism

The grass cutting mechanism in the AgriBot is designed to automate the process of trimming unwanted vegetation in agricultural fields with efficiency, precision, and minimal human intervention. This mechanism primarily consists of a high-speed DC motor coupled with a sharp cutting blade, mounted at the lower portion of the robot chassis to ensure effective contact with grass. When the system is activated, the motor rotates the blade at high speed, generating sufficient mechanical force to cut grass through continuous rotary motion. The cutting action is smooth and uniform, allowing the robot to cover large areas of farmland within a short duration.

The operation of the grass cutter is controlled electronically through a relay module connected to the microcontroller. The relay works on an active-LOW logic, meaning the cutter motor is activated when a LOW signal is sent from the controller. This configuration ensures reliable switching and protects the microcontroller from high current loads by isolating the power circuit of the motor. Commands to activate or deactivate the cutter are sent remotely via the Thinger.io, enabling the user to control the cutting process from anywhere. This remote operation significantly reduces manual effort and enhances convenience, especially in large-scale agricultural environments.

The grass cutting mechanism is also intelligently synchronized with the movement of the robot.It typically operates while the robot is moving forward, ensuring that grass is cut uniformly along its path. This coordination prevents unnecessary power consumption and avoids inefficient cutting during idle or reverse motion. Additionally, the system continuously monitors operational conditions such as battery level and connection status. In case of low battery or loss of communication, the cutter is automatically turned off to ensure safety and prevent damage to the system.

From a design perspective, the use of a relay-controlled motor provides robustness and reliability, while the high-speed blade ensures effective cutting performance. However, factors such as blade sharpness, motor efficiency, and terrain conditions influence the overall effectiveness of the mechanism. Regular maintenance, such as blade replacement and motor inspection, is essential to maintain optimal performance.

Overall, the grass cutting mechanism represents a well-integrated combination of mechanical action, electrical control, and embedded logic. Its ability to perform automated, remote-controlled, and efficient grass trimming makes it a vital component of the AgriBot system, contributing significantly to modern smart agriculture practices by reducing labor, saving time, and improving productivity.

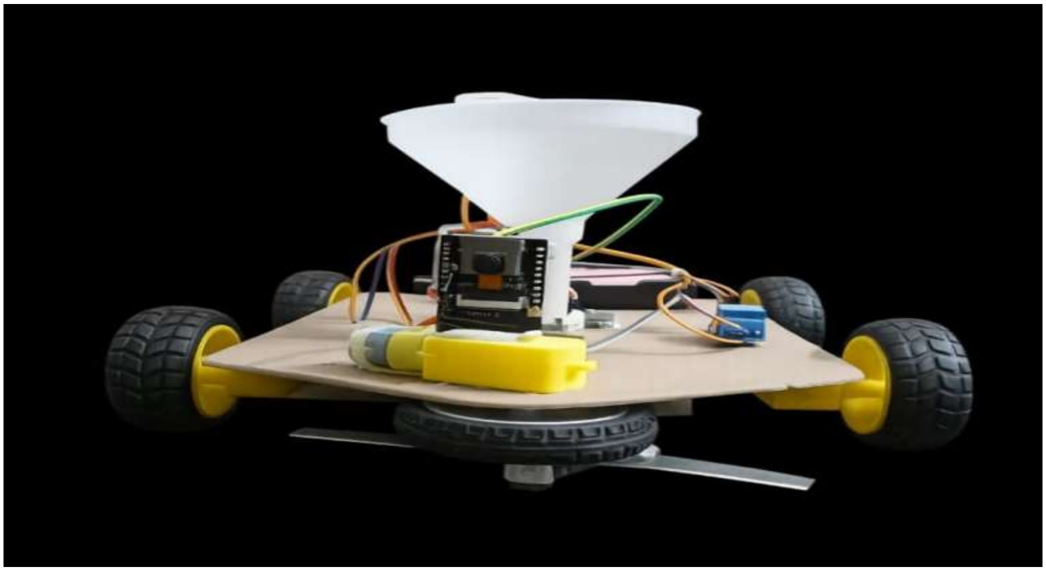

Fig: Grass cutting Mechanism

The designed system ensures effective removal of unwanted grass and weeds through the use of a motor-driven cutting mechanism, which operates efficiently while the robot is in motion. This approach significantly reduces manual labor by automating the grass cutting process, allowing farmers to manage fields with minimal human intervention. The ability of the robot to perform continuous operations while moving across the field enhances productivity and saves time compared to traditional methods. As a result, the integration of this automated cutting system provides a reliable and efficient solution for maintaining crop health and field cleanliness.

The seed sowing mechanism is an essential component of the agricultural robot, designed to ensure accurate and uniform distribution of seeds. It consists of a seed storage container connected to a controlled dispensing system that releases seeds at predetermined intervals. The mechanism is typically operated using a servo motor, which regulates the opening and closing of the dispensing outlet based on programmed instructions. This controlled operation ensures proper spacing and depth of seeds, which are critical factors for optimal germination and crop growth. By automating the sowing process, the system minimizes seed wastage, improves planting precision, and enhances overall agricultural efficiency.

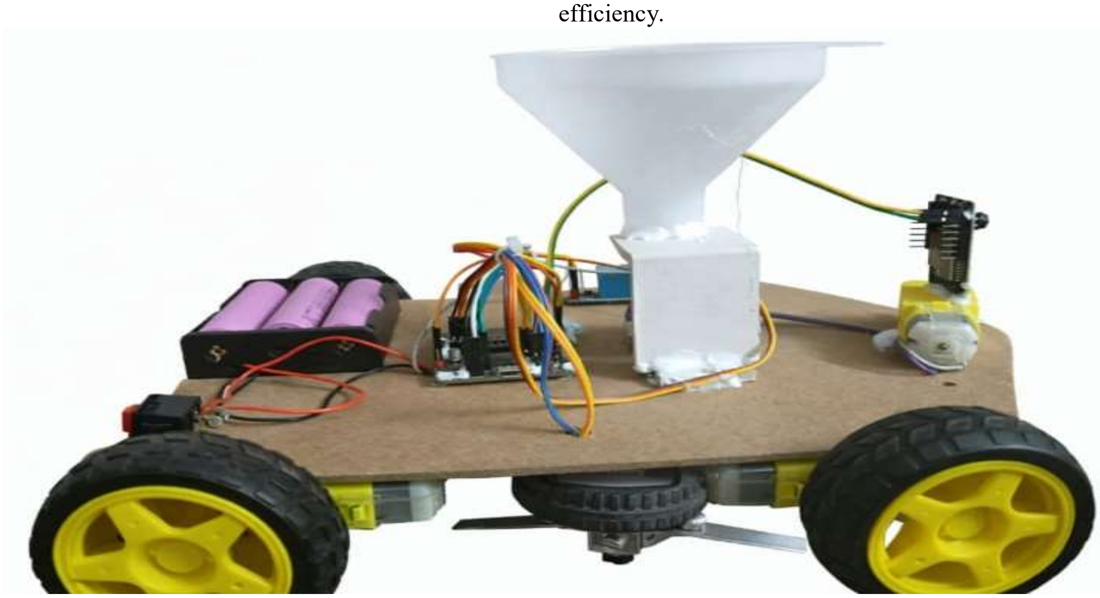

Fig: Seed sowing Mechanism

The seed sowing mechanism of the AgriBot is designed to ensure precise, uniform, and efficient distribution of seeds across agricultural fields, thereby reducing manual labor and improving crop yield consistency. This mechanism primarily utilizes a servo motor-based dispensing system that is mounted on the robot and connected to a seed storage container. The servo motor, controlled by the microcontroller through a designated PWM pin (such as D5), regulates the opening and closing of the dispensing outlet.

When activated, the servo rotates to a specific angle, allowing a controlled quantity of seeds to be released, and then returns to its original position to stop the flow. This controlled

motion ensures that seeds are dispensed in measured amounts rather than continuously, which helps maintain proper spacing and avoids wastage.A key feature of the seed sowing mechanism is its state-aware and synchronized operation with the movement of the robot. Unlike simple dispensing systems, the AgriBot's seeding logic ensures that seeds are released only when the robot is moving forward.

This prevents issues such as seed clustering in one location when the robot is stationary or reversing. The system uses an internal timing mechanism based on the microcontroller's clock (millis function) to create fixed intervals between successive seed drops. For example, seeds may be dispensed every few seconds, which corresponds to a specific distance traveled, thereby achieving uniform seed spacing across the field.

The entire seeding process is controlled remotely through the Thinger.io, where the user can enable or disable the seeder using dashboard controls. This integration allows for real-time management of agricultural operations and provides flexibility in adjusting sowing behavior based on field requirements. Additionally, the system is designed to operate in a non-blocking manner, meaning that seed dispensing does not interrupt other critical functions such as movement control or communication with the cloud. This ensures smooth multitasking and continuous operation.

From an efficiency standpoint, the servo-based mechanism offers high precision, low power consumption, and reliable performance compared to traditional methods. It also minimizes seed wastage and ensures consistent planting patterns, which are essential for optimal crop growth. Safety and reliability are further enhanced by incorporating checks such as battery monitoring and system status verification, ensuring that the seeding operation stops automatically under unfavorable conditions.

Overall, the seed sowing mechanism of the AgriBot represents an intelligent integration of mechanical design, embedded control, and IoT-based automation. By combining precise actuation, synchronized movement, and remote operability, it provides a modern solution for efficient and accurate seed distribution, contributing significantly to the advancement of smart and automated agricultural practices.
Thus, the integration of a servo-based dispensing system ensures accurate and automated seed sowing in the agricultural field.

Conclusion

The agriculture robot for seed sowing and grass cutting demonstrates the potential of automation in modern farming practices. By integrating precision technology and intelligent control systems, the robot efficiently performs tasks that traditionally require significant human labour.Although certain challenges such as terrain adaptability, maintenance, and initial costs remain, the benefits clearly outweigh the limitations. With further advancements and refinements, such robots have the potential to become a vital part of modern agriculture, supporting sustainable farming practices and helping meet the growing demand for food production in an efficient and eco-friendly manner.

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