DESIGN AND FABRICATION OF MULTIFUNCTIONAL AGRICULTURAL VEHICLE(Agribot)

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ABSTRACT:

Agriculture continues to be the backbone of economies, it remains dependent on manual labour, which is both time-consuming and physically demanding. In this context, technological intervention is necessary to enhance efficiency, productivity, and safety in agricultural practices. This project focuses on the design and development of a multipurpose agricultural vehicle that addresses multiple field-level requirements through automation and wireless control. The proposed system is a compact, battery-powered agricultural vehicle equipped with dual functionalities: a crater carrying mechanism for transportation of materials and a pesticide spraying system for crop protection. The entire vehicle is wirelessly operated via a WiFi-enabled remote-control system, providing farmers with the convenience to operate it from a safe distance without physical involvement in potentially hazardous environments, such as those requiring chemical spraying.

The core of the control mechanism is centred around an ESP 8266 microcontroller that receives commands via inbuilt Wi-Fi module from a paired Android smartphone web server or custom remote controller. This allows the user to initiate movements such as forward, backward, left, and right, along with enabling or disabling the spraying mechanism as required.

Key words: Pesticide sprayer, Crate carrier, Wi-fi module

1. INTRODUCTION:

Agriculture, being a fundamental sector of the global economy is continually evolving with the integration of modern technologies to meet the growing demands of food production and sustainable farming. Traditional farming methods, while effective in the past, are increasingly proving inadequate due to labour shortages, rising operational costs, and the need for precision and efficiency in field operations. In response to these challenges, there is a growing emphasis on the development of automated and remotely controlled agricultural machinery that can perform multiple tasks with minimal human intervention.

This project presents the design and development of a versatile, remote-controlled agricultural vehicle that addresses two critical field operations which is material transport and pest control. The vehicle is engineered to carry agricultural crates such as tools, produce, or fertilizer, while also functioning as a mobile pesticide sprayer capable of reaching and treating crops efficiently. Its mobility is powered by electric motors and is controlled via wireless hotspot using a smartphone or remote device, enabling the operator to command the vehicle wirelessly from a safe distance.

The motivation behind this innovation lies in improving the productivity of small to medium-scale farmers by offering them a low-cost, multipurpose solution that reduces physical effort, increases operational efficiency, and enhances safety. By integrating essential features into a single platform, this vehicle minimizes the need for separate equipment and enables farmers to perform daily tasks more effectively[2]. This introduction sets the foundation for discussing the system's design, components, control logic, and field-level applicability in the sections that follow.

2. MECHANICAL DESIGN:

Figure 1: 3D design of model.

The 3D model of the agricultural multipurpose vehicle was designed using CAD software(SolidWorks 2023) to visualize the structural arrangement and component placement before fabrication. The frame of the vehicle consists of a rectangular chassis constructed from square hollow metal tubes, selected for their lightweight properties and mechanical strength. The overall layout is optimized to ensure structural integrity while minimizing material usage and weight.

The vehicle is designed with four wheels, where the rear wheels are designated as drive wheels connected to 12V DC motors for propulsion. These motors are mounted in such a way that they enable differential drive operation, providing manoeuvrability by varying the speed of each

rear wheel independently. The front wheels are free-rotating caster wheels, which allow smooth directional changes without the need for active steering mechanisms. This configuration is particularly suitable for uneven agricultural terrain where agility and robustness are essential.

3.ELECTRONICS CIRCUIT CONNECTION:

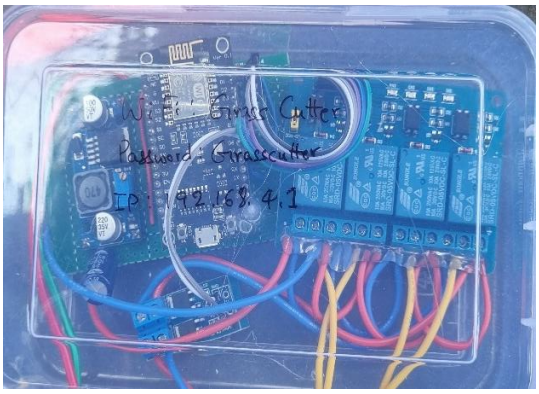

Figure 2: Electronics circuit connection

The circuit connection that has been done for the multipurpose agricultural vehicle. The core components of the system include a NodeMCU development board based on the ESP8266 Wi-Fi module, a 4-channel relay module, and a DC-DC voltage regulator. This setup is housed in a weather-resistant plastic enclosure for field usability and protection against environmental conditions.

The NodeMCU board functions as the central microcontroller and Wi-Fi host. It is programmed to act as an access point (AP) by broadcasting a predefined SSID, along with an associated IP address and password. Upon successful connection from a mobile device, the user is automatically redirected to a local web server hosted by the NodeMCU. The web interface presented to the user contains controls for the vehicle's differential drive system and a dedicated button to activate the pesticide sprayer mechanism

The 4-channel relay module is used to switch high-current loads, such as DC motors and pumps, based on digital output signals received from the ESP8266. Each relay acts as an electromechanical switch that isolates the low-power control circuit from the higher voltage and current requirements of the vehicle's actuators. The relays are connected to designated GPIO pins on the NodeMCU, which are activated through the web interface commands.

To maintain a stable voltage supply, a DC-DC voltage reducer is incorporated into the circuit. This module steps down the vehicle's battery voltage (e.g., 12V or 24V) to a regulated 5V required to power the NodeMCU and relay module reliably.

This configuration provides a cost-effective, user-friendly solution for real-time remote control of agricultural vehicle functions, promoting automation in pesticide spraying and terrain navigation using differential drive mechanics. The design emphasizes ease of use, modularity, and adaptability for various field conditions and future extensions.

4.MAIN COMPONENTS:

ESP 8266(Wifi module):

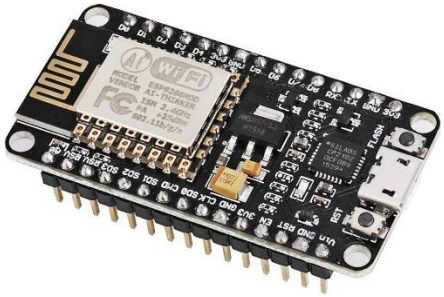

Figure 3: ESP 8266 micro controller

The ESP8266 is a low-cost Wi-Fi module developed by Espressif Systems that enables microcontrollers to connect to a Wi-Fi network. It features a built-in TCP/IP protocol stack, making it suitable for Internet of Things (IoT) applications. The module operates on 3.3V and supports both station and access point modes. It is highly popular due to its compact size, low power consumption, and ease of integration with platforms like Arduino and NodeMCU. With a powerful Tensilica L106 32-bit processor, the ESP8266 can also function as a standalone microcontroller. It supports various communication protocols such as UART, SPI, and I2C. The module allows for remote monitoring and control of devices over the internet. Its affordability and versatility make it ideal for smart home, industrial automation, and sensor-based projects.

DIAPHRAGM PESTICIDE PUMP:

Figure 4 : FUDA pesticide pump

A diaphragm pesticide pump is a type of positive displacement pump commonly used in agricultural spraying applications. It operates using a flexible diaphragm that moves back and forth to create suction and discharge actions, enabling the precise delivery of pesticides. These pumps are known for their ability to handle corrosive and abrasive liquids, making them ideal for chemical spraying. Diaphragm pumps are typically powered by electric motors or small engines and can maintain consistent pressure and flow rates. They are self-priming, capable of dry running, and resistant to wear, increasing their durability in field conditions. The sealed design prevents leaks and reduces environmental contamination. Their compact size and efficiency make them well-suited for portable and automated spraying systems.

GEAR DC MOTOR:

Figure 5: Wiper Gear DC motor

A gear DC motor is a type of electric motor combined with a gearbox to reduce speed and increase torque output. It operates on direct current and is commonly used in robotics, automation, and small machinery. The integrated gear system allows for precise control of movement and higher load handling. These motors are compact, efficient, and suitable for battery-powered applications. Their reliability and torque characteristics make them ideal for driving wheels and mechanical arms

CASTER WHEELS: Caster wheels are unpowered, rotating wheels mounted to the underside of equipment or vehicles to provide smooth and flexible movement. They can swivel 360 degrees, allowing easy steering and maneuverability, especially in tight spaces. Commonly used in carts, furniture, and robotic platforms, they support and balance loads without providing propulsion. Caster wheels come in various sizes and materials to suit different terrains and weight requirements. Their simplicity and versatility make them essential in both industrial and mobile robotic applications.

5. WORKING PRINCIPLE:

The Wi-Fi-controlled multipurpose agricultural vehicle operates using the ESP8266 NodeMCU microcontroller, which receives user commands via a mobile web interface. These commands are processed and used to control a 4-channel relay module connected to the vehicle's DC motors and pump. The relay switches the motors ON or OFF, enabling directional movement such as forward, backward, left, or right. The rear wheels are powered by 12V DC geared motors, while the front uses free-moving caster wheels for steering support.

A DC pump is activated through the relay to spray pesticides from the mounted tank. The entire system is powered by a rechargeable battery. The structural frame made of mild steel supports all mechanical and electronic components. The wireless control allows remote operation, increasing user safety and reducing manual labour. This integrated approach enhances automation and improves efficiency in agricultural operations.

Figure 6: Fabricated Model

RESULTS:

Upon completion of the fabrication, electronic integration, and coding processes, the prototype of the agricultural multi-purpose vehicle was successfully tested under controlled conditions. The results obtained demonstrate the effectiveness and reliability of the implemented systems. The table 1 represents the results obtained during the practical testing of the fabricated model.

Testing environment	**Dry cultivated soil**
Wi-Fi range	15.6 meters
Spraying power	120 Psi
Load capability	20.3 kg
Speed under no load condition	15 km/hr
Speed under the specified load	13 km/hr

Table 1: Testing results

The vehicle responds accurately to joystick movements, exhibiting smooth and stable motion across forward, backward, left, and right directions. The differential drive mechanism, powered by two 12V geared DC motors, provided adequate traction and manoeuvrability on level terrain, making it suitable for agricultural field navigation. The front caster wheels enhanced turning ability and reduced mechanical complexity, validating the chosen steering configuration.

All electronic components, including the ESP 8266, relay module, nodeMCU, and power source, operated consistently without thermal or connectivity issues. Additionally, the fabricated chassis demonstrated sufficient structural integrity. The mild steel frame provided mechanical robustness while maintaining a lightweight profile, and the anti-corrosive paint ensured material protection under outdoor conditions.

CONCLUSION:

The development of a Multipurpose Agricultural Vehicle has been successfully completed with a focus on enhancing operational efficiency and reducing manual labour in agricultural activities. The primary aim of this project was to design and fabricate a low-cost, multi-functional vehicle capable of performing tasks such as pesticide spraying, which are often hazardous and labour-intensive. Through thoughtful integration of mechanical design, electronic control systems, and wireless connectivity, the vehicle was engineered to cater to the practical needs of modern farming.

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