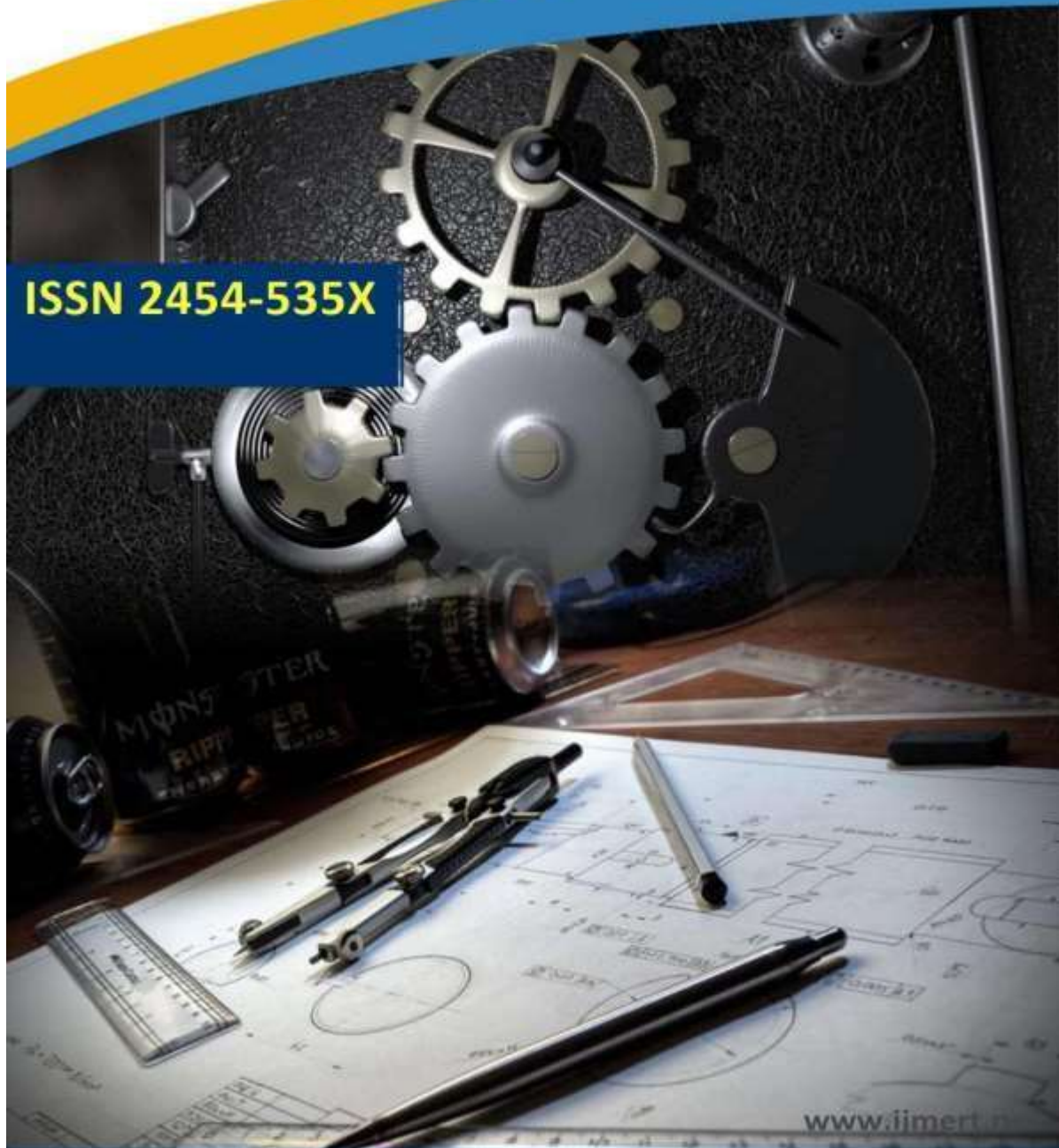




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Modelling and Development of Real time Wireless Agri Sprayer for Optimal Agricultural Operations

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Abstract

The Agri sprayer is a specialized agricultural equipment designed for the purpose of spraying various substances, such as fertilizers, pesticides, herbicides, and other liquid solutions, onto crops or agricultural fields. It plays a crucial role in crop protection and management by ensuring the effective and efficient distribution of these substances. These are indispensable tools in modern agriculture, helping farmers effectively manage pests, diseases, and weed control, while promoting optimal crop health and yield. The necessity of real-time Agri Sprayer robot with a transmitter and receiver lies in the agricultural industry's ongoing efforts to improve efficiency, precision, and sustainability in farming practices. Traditional agricultural spraying methods often involve manual labour or large machinery, which can be time-consuming, resource-intensive, and may result in uneven distribution of pesticides, fertilizers, or other agricultural inputs. This can lead to wastage, environmental pollution, and reduced crop yields. To address these challenges, the development of a Realtime Agri Sprayer robot with a transmitter and receiver has emerged as a potential solution. This robot is designed to automate the spraying process, making it more precise and efficient. It utilizes advanced technologies such as robotic body chassis design, pumping sprayer mechanism and wireless communication to optimize agricultural spraying operations.

Keywords: Agri sprayer, Optimal agriculture, Smart farming, Hybrid planetary DC motors, Spray pumps.

1. INTRODUCTION

The history of agriculture dates back thousands of years, with humans developing various techniques and tools to cultivate crops. Over time, agricultural practices have evolved with advancements in technology, leading to the introduction of machinery and automation in farming. The use of sprayers for pesticide and fertilizer application has become a common practice to ensure optimal crop health and productivity. Traditional sprayers were manually operated or attached to tractors,

limiting their flexibility and efficiency. The need for more precise and efficient spraying methods has driven the development of agri sprayer robots. Modern agriculture faces challenges such as increasing population, limited resources, and environmental concerns. To address these challenges, there is a growing demand for sustainable and efficient agricultural practices. Precision agriculture has emerged

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as an approach that utilizes technology to optimize farming operations. One aspect of precision agriculture is the development of robotic systems that can perform tasks autonomously, accurately, and in real-time. Agri sprayer robots are one such innovation that aims to optimize agricultural operations by providing precise and targeted spraying of pesticides and fertilizers.

The Realtime Wireless Agri Sprayer Robot is an advanced robotic system designed to automate and optimize the spraying process in agriculture. It utilizes wireless technology to communicate with a central control system and operates in real-time, allowing for efficient and precise spraying operations. The robot is equipped with sensors, actuators, and a spraying mechanism to deliver the desired agrochemicals in a controlled manner. It navigates through the field autonomously or with remote guidance, ensuring optimal coverage and minimizing resource wastage.

Significance

It offers several significant benefits. Firstly, it enhances the precision and accuracy of spraying operations. By utilizing sensors and advanced control algorithms, the robot can precisely identify the areas that require spraying, reducing the risk of over spraying or missing certain sections. This targeted approach minimizes the use of agrochemicals, reducing environmental impact and optimizing resource utilization. Additionally, the real-time wireless communication allows for adaptability and responsiveness to changing field conditions, ensuring optimal spraying efficiency and effectiveness.

Problem Statement

The problem statement addressed by the Realtime Wireless Agri Sprayer Robot is the need for an automated and precise spraying system in agriculture. The limitations of manual spraying and tractor-mounted sprayers

have led to inefficiencies, overuse of chemicals, and inadequate coverage. The challenge is to develop a robotic system that can navigate autonomously, identify the areas requiring spraying, deliver the agrochemicals accurately, and optimize the spraying process in real-time. The aim is to enhance crop protection, reduce chemical wastage, and improve overall agricultural productivity through advanced robotics and wireless communication technologies.

Need for the project

The need for such a robot stem from several factors:

- Precision spraying.
- Time and labour efficiency.
- Reduced environmental impact.
- Data-driven decision-making.
- Safety and scalability.

2. LITERATURE SURVEY

Adamides, George, and Yael Edan (2023) conducted a review and presented a roadmap for human-robot collaboration systems in agricultural tasks. They discussed the various applications of robots in agriculture, such as harvesting, pruning, and spraying, and highlighted the challenges and future directions for effective human-robot collaboration. Fountas, S., Malounas, I., Athanasakos, L., Avgoustakis, I., & Espejo-Garcia, B. (2022) focused on AI-assisted vision for agricultural robots. They explored the integration of artificial intelligence techniques with computer vision for tasks such as plant detection, fruit recognition, and weed identification. The paper discussed the benefits and potential applications of AI-assisted vision in agricultural robotics. Nasir, F., Haris, M., Khan, B., Tufail, M., Khan, M. T., & Dong, Z. (2023) presented a real-time plant recognition and crop row navigation system for an



autonomous precision agricultural sprayer robot. Their work utilized computer vision techniques to identify plants and navigate along crop rows, enabling targeted spraying. The paper focused on the implementation and performance evaluation of the proposed system. Alam, Muhammad Shahab, et al. (2022) introduced the TobSet dataset, which consists of tobacco crop and weeds images, and utilized it for vision-based spraying by agricultural robots. They highlighted the importance of accurate image datasets for training and testing vision-based algorithms and discussed the application of the dataset in the context of spraying tasks. Tahmasebi, Mona, Mohammad Gohari, and Alireza Emami (2022) developed an autonomous pesticide sprayer robot with a color-based vision system. Their work focused on detecting the presence of pests on plants using color information and autonomously applying pesticides. The paper presented the design, implementation, and evaluation of the vision-based spraying system.

Hizatate, Tomoaki, and Noboru Noguchi (2023) addressed the work schedule optimization for electric agricultural robots in orchards. They proposed an optimization algorithm to determine the most efficient paths and schedules for the robots to perform tasks such as harvesting and spraying. The paper discussed the benefits of optimizing work schedules in terms of energy efficiency and productivity. Navya, P., and D. Sudha (2023) presented an artificial intelligence-based robot for harvesting, pesticide spraying, and maintaining a water management system in agriculture using the Internet of Things (IoT). Their work integrated AI algorithms with IoT technologies to enable autonomous operations and optimize resource management. The paper discussed the utilization of AI and IoT in various agricultural tasks. Benos, Lefteris, Claus G. Sørensen, and Dionysis Bochtis (2022) discussed the field deployment of

robotic systems for agriculture considering key safety, labor, ethics, and legislation issues. They highlighted the challenges and considerations associated with the deployment of agricultural robots, including safety regulations, labor displacement, and ethical concerns. The paper provided insights into the practical aspects of adopting robotics in agriculture. Wang, Xuelei, et al. (2022) designed an autonomous navigation intelligent spraying robot. Their work focused on developing a robot capable of autonomously navigating in agricultural fields and performing precision spraying tasks. The paper presented the design, control algorithms, and experimental evaluation of the autonomous navigation system.

Pak, Jeonghyeon, et al. (2022) conducted a field evaluation of path-planning algorithms for autonomous mobile robots in smart farms. They compared the performance of different path-planning algorithms in terms of efficiency and accuracy for autonomous mobile robots operating in agricultural environments. The paper discussed the results of the field evaluation and provided insights into the suitability of various path-planning techniques for practical implementation. Cheng, Chao, et al. (2023) discussed recent advancements in agricultural robots and highlighted their benefits and challenges. They presented an overview of the applications of agricultural robots in various tasks, such as planting, harvesting, and spraying. The paper also discussed the challenges associated with robotic systems, including perception, navigation, and integration with existing agricultural practices. Xie, Dongbo, et al. (2022) conducted a review focused on actuators and sensors for application in agricultural robots. They discussed various types of actuators and sensors used in agricultural robotics, such as motors, hydraulic systems, and vision sensors. The paper provided insights into the selection,

integration, and performance of actuators and sensors in agricultural robot systems.

3. PROPOSED METHODOLOGY

The real-time Agri sprayer robot operates through the integration of various hardware and software components. Figure 1 shows the block diagram of agri sprayer. The hardware modules include an Arduino UNO controller, a 6-CH transmitter and receiver for communication, hybrid planetary general DC motors, a motor driver for motor control, a power supply for providing electrical power, a relay module for switching the spray pumps on and off, spray pumps for dispensing the liquid solution, a robot body chassis constructed through CNC laser cutting and metal bending, and 3D printed brackets, clamps, and solid parts for additional support and functionality. On the software side, Catia V5 is utilized for mechanical design, parts design, sketching, assembly design, drafting, and generative sheet metal design. It allows for the creation and visualization of the robot's physical structure and components.

The Arduino IDE (Integrated Development Environment) is employed for programming the Arduino UNO controller. This software facilitates the writing, editing, and uploading of the code necessary for controlling the robot's movements, pump activation, and overall operation. By combining these hardware and software elements, the real-time Agri sprayer robot is able to function effectively. The Arduino UNO controller acts as the central control unit, receiving commands from the transmitter via the receiver and executing the appropriate actions. The motor driver enables precise control over the DC motors, allowing for smooth and accurate movements. The power supply provides the necessary electrical energy to power the various components of the robot. The relay module enables the activation and deactivation of the spray pumps. The robot

body chassis, constructed with CNC laser cutting, metal bending, and 3D printed parts, provides a sturdy and functional structure for the robot. Overall, the real-time Agri sprayer robot combines both hardware and software components to create an autonomous agricultural spraying system that can navigate fields, activate spray pumps, and efficiently distribute liquid solutions for crop protection and management.

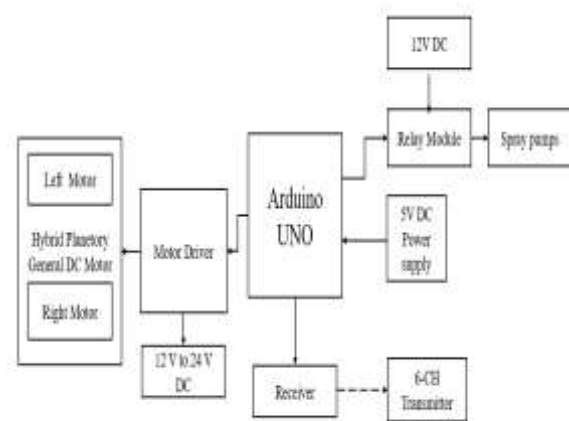


Figure 1: Block diagram of Agri sprayer.

Methodology

Arduino UNO controller: The Arduino UNO serves as the main controller of the Agri sprayer robot. It receives inputs, processes data, and controls the various hardware components accordingly.

6-CH transmitter & receiver: The transmitter allows the operator to send commands wirelessly to the robot, while the receiver receives these commands and relays them to the Arduino UNO for further processing.

Hybrid planetary general DC motors: These motors provide the necessary mechanical power for the movement of the Agri sprayer robot. They are responsible for driving the wheels or tracks and other movable parts.

Motor Driver: The motor driver module acts as an interface between the Arduino UNO and the



motors, allowing the controller to control the speed and direction of the motors.

Power supply: The power supply module provides the necessary electrical power to all the components of the Agri sprayer robot, ensuring their proper functioning.

Relay module: The relay module is used to control the operation of the spray pumps. It enables the Arduino UNO to switch the pumps on or off as needed.

Spray pumps: The spray pumps are responsible for pumping the liquid solution, such as pesticides or fertilizers, from the tank and spraying it onto the crops or agricultural fields.

Robot body chassis: The robot body chassis provides the structural support and framework for the Agri sprayer robot. It houses and protects the various hardware components.

CNC laser cutting: CNC laser cutting technology is used to precisely cut and shape the metal parts of the robot body chassis, ensuring accuracy and efficiency.

CNC metal bending: CNC metal bending is utilized to bend and shape metal components, such as brackets and clamps, with precision, enabling proper fitting and assembly.

3D printed brackets, clamps, and solid parts: 3D printing technology is employed to create customized brackets, clamps, and other solid parts required for the assembly and operation of the Agri sprayer robot.

Catia V5: Catia V5 is a software used for mechanical design, parts design, sketching, assembly design, drafting, and generative sheet metal design. It is employed to design and visualize the various components and structures of the Agri sprayer robot.

Arduino IDE: The Arduino Integrated Development Environment (IDE) is the

software platform used for programming and uploading code to the Arduino UNO controller. It provides a user-friendly interface for writing, compiling, and uploading the necessary code to control the robot's behavior and interaction with the hardware components.

Algorithm

step 1: Initialization: The robot is powered on, and the Arduino UNO controller initializes the system by running the preloaded software code.

step 2: Communication: The 6-CH transmitter allows the operator to wirelessly send commands to the robot. These commands are received by the receiver module connected to the Arduino UNO controller.

step 3: Command Processing: The Arduino UNO controller processes the received commands, interpreting them as instructions for the robot's movements and spraying operations.

step 4: Motor Control: The motor driver connected to the Arduino UNO controller regulates the power and direction to the hybrid planetary general DC motors. This control enables the robot to move forward, backward, turn left, turn right, or perform other maneuvers as commanded by the operator.

step 5: Navigation: Based on the received commands, the robot's motor mechanism determines the direction and maneuverability of the robot. This allows the robot to navigate through the fields, covering the desired areas for spraying.

step 6: Spray Pump Activation: The relay module, controlled by the Arduino UNO controller, switches the spray pumps on and off. When instructed, the relay module activates the spray pumps, allowing them

to dispense the liquid solution onto the crops.

step 7: Spraying Operation: As the robot moves through the field, the activated spray pumps distribute the liquid solution evenly onto the crops. This ensures that the crops receive the required number of agrochemicals for effective pest and weed control.

step 8: Autonomous Operation: The robot operates autonomously, following the programmed instructions and predefined paths. It continues to move, spray, and cover the designated areas until the task is completed or until instructed otherwise by the operator.

step 9: Monitoring and Safety: The Arduino UNO controller constantly monitors the robot's status and sensors. It incorporates safety features to prevent collisions or accidents, such as obstacle detection sensors or emergency stop mechanisms.

step 10: Real-time Feedback: The robot may be equipped with sensors or cameras to provide real-time feedback on the spraying process, field conditions, or any potential issues. This feedback can be transmitted to a monitoring system or displayed to the operator for analysis and decision-making.

4. IMPLEMENTATION AND RESULTS

CNC Metal Laser Cutting

CNC (Computer Numerical Control) laser cutting is a highly precise and efficient manufacturing process that uses a laser beam to cut through various materials with exceptional accuracy. In the context of designing and fabricating a wireless pick and place robot, CNC laser cutting plays a crucial role in creating the necessary components for the robot's structure and functionality. When it comes to designing the robot, engineers and

designers can use computer-aided design (CAD) software to create detailed 2D or 3D models of the robot's parts. These models can then be converted into machine-readable instructions that guide the CNC laser cutting machine.

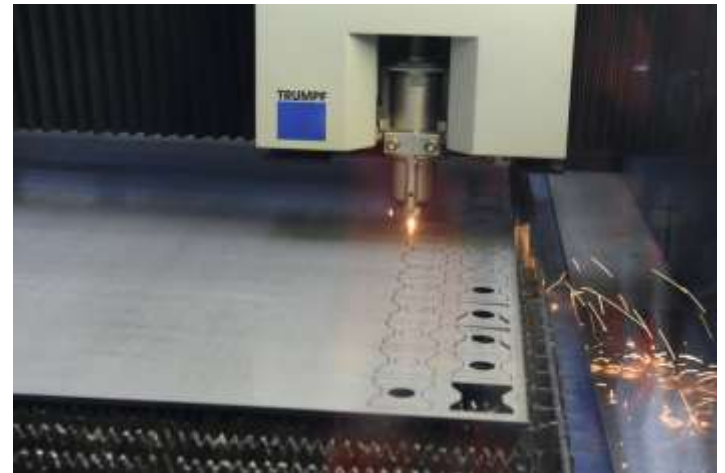


Figure 2: Procedure of CNC laser cutting.

The CNC laser cutting machine operates by directing a high-powered laser beam onto the material to be cut. The laser beam is controlled by a computer program that precisely determines its movement and intensity. As the laser beam interacts with the material, it generates an intense heat that melts or vaporizes the material along the predetermined cutting path. The focused laser beam can cut through various materials, including metals, plastics, and wood. By utilizing CNC laser cutting, the robot's structural components can be accurately manufactured with intricate details and precise dimensions. For example, the robot's chassis, which provides the framework and support for other components, can be fabricated from a sturdy metal sheet using CNC laser cutting. The laser cutting process ensures clean and smooth edges, minimizing the need for additional finishing or post-processing. Moreover, CNC metal laser cutting enables flexibility in design iterations. If modifications or improvements are required during the prototyping phase, the laser cutting

machine can quickly adapt to the changes and create revised components without extensive retooling or setup time.

CNC Metal Bending

Due to advanced technologies and inventions, the world has seen numerous changes for the better. Thanks to these technologies, industries around the world have been introduced to numerous aids, solutions, and tools that have made operations easier, more efficient, and even environment friendly. One such tool is the CNC Bending Machine. CNC Hydraulic Bending Machine and CNC Bending Machine have been around for a while but have become better and better with time and advancement. It is a machine that helps bend cold sheets of metals into desired geometric and cross-sectional shapes. It has several uses which are needed in various industries such as manufacturing, automobile, railway, aircraft, shipbuilding, and so on.

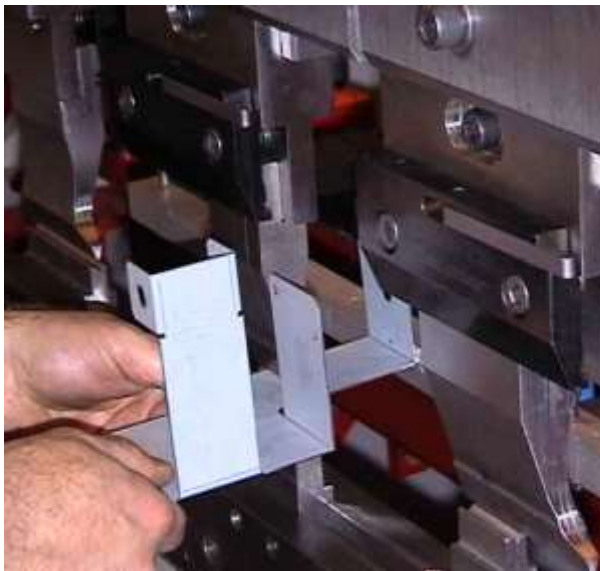


Figure 3: CNC metal bending process.

Some of the features for CNC sheet metal bending machines are:

- A powerful CNC control system for precise control and supervision of the bending and pressing.
- Excellent back gauge adjustments to help suit your needs.
- Consistent parallel and precision run with a reliable crowning system.
- Has top-class optical safety without disrupting performance or productivity.
- Smart Tooling App from WILA for efficient management of inventory and quick data entry.
- An improved system for tooling clamping.
- All products have Hybrid Eco Function to support the environment and be eco-friendly.
- Active angle Control for better angle management and measurement.

CNC bending, also called CNC forming, is the process whereby sheet metal is reshaped from a flat form. Using CNC bending technology you can produce almost any component design. A basic example of this would be the creation of a 90-degree bend transforming a flat piece of metal into an 'L' shaped bracket.

Powder Coating

Powder Coating is a dry finishing process created by an electric charge that causes a dry powder to fuse to the surface of the metal. This is then baked in a curing oven to achieve a smooth coating. It is usually used to create a hard finish that is tougher than conventional paint. Powder coating does not have a liquid carrier, meaning it can produce thicker coatings than conventional liquid coatings without running or sagging. It produces minimal appearance differences between horizontally coated surfaces and vertically coated surfaces. Powder coating is a surface finishing option that applies a relatively thin film to provide excellent corrosion protection and chemical resistance in a highly cosmetic manner. While parts are often designed with specific colors, gloss, and textures – the types of powder coating are

often overlooked, yet a critical component to every powder coating job. Powder coatings are applied in a variety of types. Each resin system has specific attributes that are able to better suit needs of specific environments.

6-CH Transmitter and Receiver

A wireless pick and place robot is a robotic system that can autonomously move objects from one location to another. To control such a robot wirelessly, we use a transmitter and a receiver. In this case, we specifically use a 6-channel transmitter and receiver. The transmitter is a device that you can hold and use to send commands to the robot. It has six different channels or buttons that you can press to control various functions of the robot. Each channel corresponds to a specific action or movement that the robot can perform. For example, moving the robot forward, backward, left, right, picking up an object, and placing an object. The receiver, on the other hand, is a device installed in the robot. It receives the signals sent by the transmitter and interprets them as commands for the robot to execute. The receiver is connected to the robot's control system, allowing it to activate the necessary motors or actuators to carry out the desired actions. In the design and fabrication of the wireless pick and place robot, the 6-channel transmitter and receiver play a crucial role. They enable the operator or user to control the robot remotely without the need for physical connections. This wireless control allows for greater flexibility and freedom of movement. During the fabrication process, the transmitter and receiver are carefully integrated into the robot's electronics. The receiver is usually placed inside the robot's main body, while the transmitter is designed to be portable and handheld. They communicate with each other using a wireless communication protocol, such as radio frequency or Bluetooth, depending on the specific implementation.



Figure 4: Hardware prototype of Agri sprayer.



Figure 5: Agri sprayer with an operation of sprinkling pesticide/water.



Figure 6: Agri sprayer with and operation of climbing slopes.

5. CONCLUSION AND FUTURE SCOPE

In conclusion, the development of a Realtime Agri Sprayer robot with a transmitter and receiver holds great potential for revolutionizing agricultural spraying practices. By incorporating automation, wireless communication, and advanced spraying mechanisms, this technology aims to enhance precision, efficiency, and sustainability in crop protection and management. The Realtime Agri Sprayer robot offers several advantages over traditional spraying methods. It eliminates the need for manual labor and reduces the dependence on large machinery, resulting in cost savings and increased productivity. The precise control and distribution of substances such as fertilizers and pesticides ensure optimal utilization and minimize wastage, leading to improved crop health and higher yields. Additionally, the



wireless communication capabilities enable real-time monitoring and control, allowing for timely adjustments and interventions.

The future scope of Realtime Agri Sprayer robots is promising. Further advancements can be made in areas such as autonomous navigation, intelligent spraying algorithms, and integration with sensor technologies for real-time monitoring of crop health and environmental conditions. The incorporation of artificial intelligence and machine learning algorithms can enable the robots to analyze data and make informed decisions regarding optimal spraying patterns and substance application. Moreover, the integration of Internet of Things (IoT) technologies can facilitate seamless connectivity, data exchange, and remote monitoring and control of multiple robots operating in different agricultural fields. By continuously refining and expanding the capabilities of Realtime Agri Sprayer robots, we can expect to witness significant improvements in agricultural spraying operations. This technology has the potential to contribute to sustainable farming practices, reduce the environmental impact of chemical applications, and ultimately enhance food production to meet the growing global demand.

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