Smart Arecanut Orchard Management Using an ESP32-Based Remote-Controlled Spraying Machine

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Abstract
Arecanut is one of the major plantation crops cultivated extensively in South India. However, arecanut plantations are highly susceptible to various diseases, making pesticide application an essential agricultural practice. Traditionally, pesticide spraying is performed manually, requiring labourers to climb tall arecanut trees. This approach is labour-intensive, time-consuming, costly, and poses significant safety risks. Although mechanized spraying systems have been introduced, conventional petrol-engine-based machines are generally heavy, expensive, and difficult to operate.
In order to overcome the limitations mentioned above, this paper suggests using a battery-operated remotely controlled pesticide spraying system for arecanut plantation. In the proposed setup, the receiver unit is made up of the ESP32 microcontroller, and the transmitter is set up in the form of the ESP32 as a web server. Spraying process can be done through a mobile phone which will communicate with the ESP32 web server. Depending upon the command provided, the receiver unit will control the motor and accordingly rotate the wheels either in clockwise or anticlockwise direction in order to fix the height of the spraying unit. After reaching the required height, pesticides will be sprayed through four nozzles which operate through the solenoid valves. For continuous supply of pesticides in the spraying system, pressure pump is used. The system is portable as its structure is detachable and attachable.

Keywords: Arecanut Plantation, ESP32, Pesticide Spraying Machine, Remote-Controlled Agriculture

1. Introduction

Agriculture still acts as the main means of earning money for a considerable number of people residing in the rural areas of South India, mainly in the states of Karnataka and Kerala. Among all the plantation crops that are grown in these areas, arecanut occupies an important place in the economy of agriculture. But the cultivation and maintenance of arecanut plantation entails many labor-intensive processes, including harvesting, spraying pesticides and fertilizers. Usually, all these tasks can be performed only by qualified workers who are able to ascend the trees and do all the tasks in the crown of the tree.
Normally, arecanut trees reach a height of 12 to 15 meters (40–50 feet), and therefore, ascending these trees is a difficult and sometimes dangerous process. The worker may have to ascend from 100 to 150 trees a day in a plantation where there are more than 500 trees per acre. Such a process often causes tiredness, a high risk of accident, and inefficiency. In addition, the shortage of skilled labourers and the absence of interest of young generation in agriculture has aggravated the problems of arecanut growers. As a result, the cost of labor has become rather high.
Some of these issues have been addressed through various mechanical and semi-automated solutions offered by both farmers and agricultural researchers. Despite these efforts, the majority of the conventional systems have exhibited some disadvantages such as high costs, heavyweights, complicated operations, lack of maneuverability and poor spraying efficiency. Traditional spraying machines which are petrol engine powered are usually costly, loud and bulky hence hard to transport within plantation areas. There is therefore an increased need for an efficient, lightweight and affordable system that will carry out pesticide spraying effectively and safely.
The work describes the design and construction of a battery powered remotely controlled arecanut tree pesticide spraying machine. This machine uses ESP32 microcontrollers for wireless communication and control purposes. Commands are sent using a mobile phone-based web interface whereas the receiver unit operates the motion and spraying of the machine. A pressure pump and spray nozzles have been fitted on this machine to provide efficient pesticide spreading at the correct heights. The light and detachable design of this machine makes it easily portable and convenient to use.

2. Related Work

Yang Guohao et al. [1] explored the use of Radio Frequency Identification (RFID) technology in Intelligent Transportation Systems (ITS). The paper stressed the significance of the use of RFID controllers to facilitate wireless and two-way communication between devices involved in identification and information exchange.
Ramarathnam Srivatsan et al. [2] worked on a model for diagnosing leaks in air brake systems. It was pointed out that a dependable braking system is essential for road safety. The authors suggested a technique to determine the degree of leak based on the deviation from the normal levels of pressure in the brake chambers and supply line.

Haishui Zhu et al. [3] developed an effective and cost-efficient DC motor system for the purpose of carrying golf bags. The PI control scheme using an operational amplifier circuit was used to control motor speed based on input values.

Xiyu Liu et al. [4] performed an analysis of the parameters having impact on the reliability and service life of Valve Regulated Lead-Acid Batteries (VRLA). It was discovered that the factors such as temperature, charging process, and internal protection are particularly important for these batteries.

Li Jishun et al. [5] suggested a multi-body dynamic analysis approach for drum brakes. Kinematic and dynamic simulations of the process provided valuable information about the interactions of the components and the effect of the rotational mass.

Joydeb Mandal et al. [6] described the design and thermal analysis of electromagnetic copper solenoids used in gyroscopes. The process included the modelling of magnetic field and the thermal simulation carried out with the use of ANSYS and FloEFD software to ensure the proper operation of the device at high temperatures.

Various types of lithium ion batteries along with their suitability in certain situations were analyzed by Arna-Irina Stan et al. [7]. Comparison was done among different kinds of lithium ion batteries such as lithium cobalt oxide, lithium iron phosphate, and lithium nickel manganese cobalt oxide with respect to the energy density, safety, charge, and performance.

A fuzzy logic based tilt control method for tree-pruning robots was proposed by Pengfei Gui et al. [8]. Dual fuzzy control approach helped to handle both static and dynamic tilting problems faced during the climbing process.

Modal analysis was conducted on heavy-duty automobile brake drums by Zheng Bin et al. [9]. Dynamic behavior of the brake drums was studied through the calculation of the first twelve natural frequencies and related vibration modes.

Design and fabrication of a four degree of freedom robotic arm for coconut harvesting was performed by S. Parvathi et al. [10]. Inverse kinematics and PIC18 microcontroller were used in the automated harvesting process of coconuts.

Yallappa D. et al. [11] studied the design and performance analysis of drones used in pesticide spraying. The hexacopter proposed in this study had a BLDC motor, LiPo battery, pesticide container, and spraying mechanism that helped in aerial spraying of pesticides with a carrying capacity of around 5 kg.

Upasana Sarma et al. [12] designed a speed control mechanism for a PMDC motor based on a PIC microcontroller and a PID controller. Infrared sensors were used to give feedback to achieve precision in speed control and positioning for industry purposes.

Madhu Babu V. et al. [13] designed a self-tuning PID controller for augmented reality-based UAV. Tuning of the controller parameters was done by using a gradient descent algorithm for optimization.

Shwetha B. et al. [14] designed a smart pesticide sprayer for arecanut plantation. The vertical motion of the sprayer and pesticide nozzle were controlled using an AT89S52 microcontroller wirelessly.

A carrier system model that integrates a DC gear motor has been designed by Chenfeng Yao et al. [15]. Using gearbox and DC motor, the system provided low rotational speed and high torque making it ideal for conveyor and material handling.

An Arduino Uno based DC motor control system for wire feeding machines was demonstrated by Mohamed Mezaache et al. [16]. The paper discussed the problems arising from static friction, variable inertia and load disturbances and at the same time maintained speed control using chopper drive motors.

Sudharani Pottur et al. [17] have made a thorough review of IoT based monitoring and control systems of induction motors. Different hardware devices such as Raspberry Pi, Arduino Uno and NodeMCU were analyzed in the context of their strength and weaknesses.

Chi Jie Tan et al. [18] introduced a remote control system using Wi-Fi that applied frequency synthesis method. The system used ESP8266 module and TCP/IP protocol to provide wireless control of electrical machines.

Security aspects of ESP32-based IoT devices have been explored by Oleksii Barybin et al. [19]. This study has demonstrated the enhanced performance of ESP32 over ESP8266 concerning processing capabilities, connectivity, and device management while discussing some security aspects related to them.

Acanut tree climbing robot equipped with a nozzle mechanism of pesticide spray using a servo motor was designed by Atreya G. Bhat et al. [20]. The robot is based on an 8 Nm torque motor and provides the scope of enhancing climbing capability by using proper gear transmission systems.

The braking performance of the combined electronic hydraulic braking system of electric vehicle has been studied by Li Chao et al. [21]. Using MATLAB/Simulink, AMESim, and CarSim simulation software, the study has analyzed different cases including regenerative braking and collision avoidance.

Harvesting technologies for arecanut have been described by Pooja Pawar et al. [22]. These researchers pointed out that despite the emergence of several new and innovative climbing and harvesting devices, they are very expensive in nature, which restricts their use among small-scale farmers.

An integrated device for arecanut tree climbing and spraying was created by Pallavi H. G. et al. [23]. It comprised a hexagonal frame base, three DC motors, nylon wheels with rubber gripping and IR controlled relay system that would control climbing and spraying process.

A pneumatic-controlled arecanut harvesting robot using Raspberry Pi was created by L. Yashaswini et al. [24]. It used six pneumatic cylinders that facilitated gripping, climbing and cutting tasks and offered an automated solution for arecanut harvesting.

A semi-automated tree climbing and harvesting machine for arecanuts was created by Mohit Rane et al. [25]. It offered remote control and camera system that allowed monitoring the harvesting process without being on the ground which increased the safety of operation.
An electromagnetic braking system was designed by Sanket Kumbhar et al. [26] to improve braking efficiency of heavy vehicles and reduce the usage of mechanical brakes and their wear thus increasing the safety of the vehicle.
Acanut tree-climbing and pesticide-spraying machine based on 12V rechargeable battery power source was designed by K. Yatish et al. [27]. The climbing system involved the use of friction between tree and motorized wheels.
An automated climbing tree and pesticide-spraying device using a rechargeable battery as power source was designed by Arshiya Siddiqa et al. [28]. The machine used a microcontroller and RF transceiver to operate wirelessly and remotely.

The controllable wiper arm reverse design for automobile was introduced by Tsutomu Tashiro et al. [29]. The control technique was designed using attitude feedback and speed regulating methods to enable the control of the wiper arm movements.
Relly Victoria Virgil Petrescu et al. [30] introduced a mechatronic brake system, which is composed of mechanical and electronics to improve the vehicle brake efficiency. The study focused on the need for proper energy management and dynamic forces control of the braking systems.
Bhushan E. Lokhande et al. [31] studied non-contact electromagnetic brakes. From their research, they discovered that electromagnetic brakes are able to lessen the load of the traditional friction brake resulting in lessening the chances of getting heated.
A. Sathishkumar et al. [32] developed an arecanut climbing and harvesting machine with pesticide spraying attachment. They used rope and pulley system to change the rotational motion to the vertical motion for effective climbing with minimal effort.

2.1 Research Gap

Although numerous studies have explored tree-climbing robots, pesticide-spraying systems, wireless controllers, and battery-powered agricultural machines, most existing solutions suffer from one or more limitations such as high cost, excessive weight, complex mechanical structures, limited portability, and dependence on skilled operators. Furthermore, many systems focus exclusively on harvesting or climbing operations without providing an integrated, lightweight, and remotely controlled pesticide-spraying solution. Therefore, there remains a need for a cost-effective, battery-operated, ESP32-based smart spraying machine that offers easy installation, remote operation through a mobile interface, enhanced safety, and efficient pesticide application for arecanut plantations.

Table 1 Literature Survey

Reference Name	Method	Purpose
Yang Guohao.et al [1]	Radio Frequency Identification technology and its application	To build an anti-collision system.
Srivatsan Ramarathnam.et al [2]	Overview of Air brake model and its advantages.	Improve the safety of truck brake systems.
Zhu Haishui.et al [3]	Cost-effective DC motor for use in different purposes	The motor should run at a maximum current of 50A for 5s
Xiyu Liu. et al [4]	Failure of VRLA battery and methods to increase the lifetime of the battery	To study the advantages and disadvantages of VRLA batteries.
Li Jishun .et al [5]	Drum braking system multi-body dynamic modeling concept	Study about moment of inertia in the brake
Joydeb Mandal.et al [6]	electromagnetic copper solenoids for gyroscope devices	Solenoid applications.
Ana-Irina Stan.et al [7]	overview of lithium-ion batteries	Analysis of advantages of lithium-ion batteries
Pengfei Gui .et al [8]	Fuzzy controller	To design a robot that is used for tree pruning.
Zheng Bin. et al. [9]	Natural frequencies and vibration modes	Designing brake drums to choose appropriate parameters
S. Parvathi . et al. [10]	The inverse kinematic calculation for four degrees of freedom	To provide the necessary equipment for harvesting
Yallappa D .et al [11]	BLDC motor, LiPo (lithium polymer) battery and drone sprayer.	To design a hex copter drone for agriculture purposes.
Upasana Sarma.et al [12]	PLC and PIC Microcontroller	Study and implementation of microcontrollers.
Madhu Babu V.et al [13]	Proportional Integral Derivative Controller	To build an AR Drone Quadrotor
Shwetha B . et al. [14]	AT89S52 microcontroller and RF transceiver.	Construction of an efficient chemical arecanut sprayer.

Chenfeng Yao.et al [15]	A typical conveyor system's operating logic and a DC gear motor.	Overview of DC gear motor.
Mohamed Mezaache.et al [16]	Permanent magnet DC motor.	DC motor applications and their implementation.
Sudharani Pottur.et al [17]	IoT is used to monitor electric motors across a range of industries.	The pros and cons of RaspberryPi, Arduino uno, NodeMCU
Chi Jie Tan .et al [18]	Frequency synthesis is used to select channels in remote-controlled systems.	Understanding of TCP/IP protocol.
Oleksii Barybin.et al [19]	ESP32 and IoT.	Applications of ESP32
Atreya G Bhat .et al [20]	Servo control nozzle	Use Bluetooth and WiFi to save further money on an RC remote controller.
Li Chao. et al [21]	Hydraulic Brake System	Implementation of hydraulic brake system.
Pooja Pawar .et al [22]	Cultivation practices like climate and soil.	To design a low-cost arecanut tree-climbing robot.
Pallavi H G .et al [23]	Hexagonal shape machine with hinges	Design of a specially shaped robot with minimal weight.
L. Yashaswini. et al [24]	The Android application RaspiCAM Remote	Advantages and Disadvantages of RaspiCAM in tree climbing robot.
Mohit Rane . et al. [25]	Semi-automated tree-climbing plucker	The machine should have a grip over the tree surface.
Sanket Kumbhar.et al [26]	Electromagnetic brakes over friction brakes	Implementation of brake system in tree climbing machine.
K Yatish . et al [27]	Relative lateral movement between the two in contact solid boundaries.	Machines should be operated by unskilled labour safely and efficiently.
Arshiya Siddiqa . et al. [28]	RF Transceiver and microcontroller.	To make a wireless connection between transmitter and receiver.
Tsutomu Tashiro.et al [29]	Controlling the reverse of the wiper arm.	Wiper controller design with controllable wiper arm
Relly Victoria Virgil Petrescu .et al [30]	Kinetic energy	Types of Brakes in Mechatronic System.
Bhushan.E.Lokhande.et al [31]	Electromagnetic braking	Implementation of Electromagnetic braking system
C Sathishkumar . et al. [32]	Rope and pulley mechanism	Arecanut harvesting machine.

3. Motivation and Contribution

Cultivation of arecanut is one of the important agricultural practices in South India. But pesticide spraying for maintaining health becomes difficult since arecanut plants usually reach a height of 12-15 metres (40-50 feet). The workers have to climb up the tree manually to reach the topmost part of the tree for pesticide spraying. This is not only a tough task but also is dangerous. Also, availability of skilled workers who can do this task has been decreasing continuously, which makes this process costly and delay in pesticide spraying.

This spraying of pesticides by manual methods also makes the workers expose themselves to hazardous substances which might be dangerous for their health. There are other dangers too while climbing on a tall tree.

In order to tackle the problem of manually spraying pesticides on arecanut plantations, this project puts forward the idea of developing a lightweight battery-operated remote-controlled spraying machine. This machine is equipped with an ESP32 controller and is capable of being controlled through a mobile phone utilizing a web server. It reduces the labor requirement, enhances safety, ensures protection from pesticide exposure and improves the efficiency of spraying.

Some of the contributions made by this work are as follows:

1. Development of a lightweight battery-operated mechanism to climb arecanut trees.
2. Use of ESP32 controller based wireless system to control the machine remotely.
3. Use of pesticide spraying mechanism consisting of a pressure pump and several spray nozzles.
4. Inclusion of a braking system that can keep the machine stationary at the desired height.
5. Use of a mechanism which can be attached to and detached from arecanut trees easily.

The steps involved in the operation of the proposed system are as follows:

- The machine is attached to the arecanut tree.
- The climber initiates the climbing operation by giving commands using a mobile phone.
- The ESP32 sensor triggers the drive motors.

- The machine climbs up to the required height.
- The braking system keeps the machine in place.
- The pressure pump delivers the pesticide to the nozzles for spraying.
- Once the spraying process is completed, the machine comes down safely after releasing the brake.

The proposed system offers a practical and economical means of pesticide spraying in arecanut cultivation.

4. Proposed Methodology

4.1 Experimental work

The design of the system under consideration was done using the Arduino IDE along with the ESP32 board support package and necessary software libraries. The ESP32 module was programmed to act as a local web server, providing wireless communication between the mobile phone and climbing machine. The friendly web interface was created to send commands controlling the climbing machine, brakes, and pesticide spraying process. The communication between the transmitter and receiver was done through Wi-Fi without the necessity of connecting to the Internet.

4.2 Overview of the machine

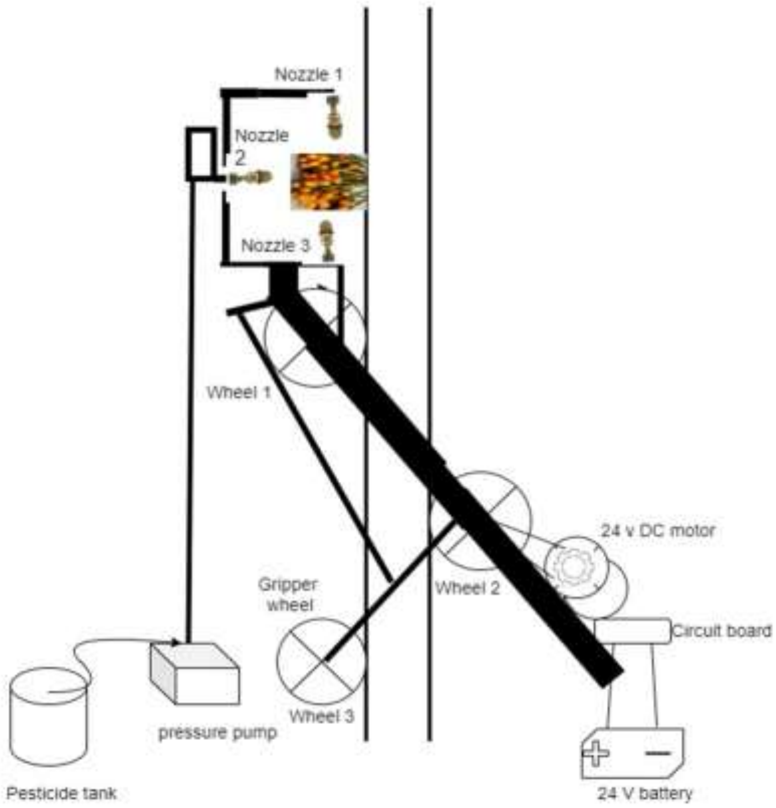

Figure 1. Block diagram of the machine

Figure 1 shows the main climbing process of the proposed machine. Climbing module has three wheels attached to a V shaped frame. The two wheels are powered by DC motor whereas the third wheel helps in increasing the friction for better climb on tree. This frame works as the mounting base for spraying module.

The working principle of the spraying module includes pressure pump, solenoid valves and spray nozzles. The pressure pump provides the pesticide to the nozzles from the storage tank via solenoid valves. After the spray command is given, solenoid valves open and pesticide reaches the nozzles through which pesticide is sprayed on the desired part of arecanut tree.

Two motors have been used in the machine for their respective purposes. A 24 V DC geared motor is used for climbing module to move vertically up on the tree. A wiper motor is used to function as brake mechanism for holding the machine in desired height position for spraying process. Both the motors work independently using 12 V relay modules.

The connection between the mobile phone and the ESP32 web server occurs via the Wi-Fi network. Via the web application, the operator will be able to send instructions to move the machine upwards and downwards, engage and disengage the brakes and spray the pesticides. The local wireless network being utilized by the system makes it possible to deploy the system in plantations without needing to have access to the internet.

The ESP-WROOM-32 serves as the receiver as well as the controller of the entire system. Instructions sent through the mobile application web interface will be received by the ESP32, and will control the wheel motors, brakes, and spray mechanism using relay circuits. The wheels will be able to move in both clockwise and anticlockwise

directions depending on the instructions sent. Once the machine gets to the desired height, the brakes will be engaged and the spraying of pesticides will be done using the nozzles.
The entire structure is relatively small and can be easily fixed or removed from the tree trunk. The wireless communication range of the ESP32 system was discovered to be about 50-150 m in average conditions and therefore can be used in arecanut cultivation fields. The suggested device offers a convenient solution to ease manual labor during pesticide application process.

4.3 Transmitter

Figure 2. Transmitter

Figure 2 is the transmitter part of the machine. The ESP 32 Wroom can support a web server, which means connected devices may be approached and controlled wirelessly. Because the ESP has built-in WiFi capability, it will create a local network that can be accessed via a web browser. The functionality can be programmed using Arduino IDE. The server can communicate real-time data and user instructions or execute preprogrammed actions. The ESP32 WROOM module integrates seamlessly into IoT projects, using its built-in Wi-Fi capability to host a web server. This makes the IoT capability of the circuit, device, or system wireless and accessible via a web browser. The ESP32 allows for direct connections by setting up a local network without external infrastructure, making it more accessible and flexible to deploy. Sensor monitoring, multimedia streaming, and other applications can be made in real-time by empowering these data transmissions. User interaction is powered by web interfaces facilitating control and customisation. When developing web pages, user actions are predefined to respond to inputs or programmed logic, which can encompass turning off devices or raising alarms, among others. The ESP32 WROOM module is an all-around IoT solution that makes it very easy to use, has good wireless connectivity, and has web-based control. It is perfect for all IoT projects and applications.

4.4 Receiver

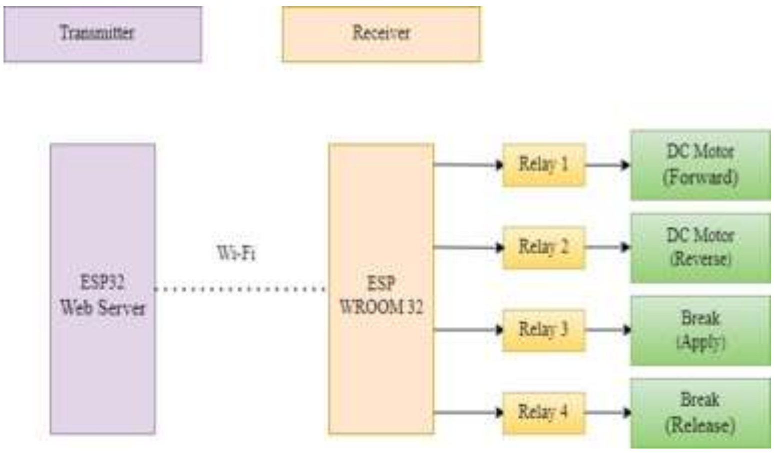

Figure 3. Receiver

Figure 2 shows the block diagram of the transceiver. The ESP32 receiver activates the appropriate optocoupler relays according to the signal or command from the transmitter. Optocoupler-driven relays have a limited capacity. In the output port, the relays used have power. Power relays are on and off using small relays. The command will be received through a four-channel, 12-volt optocoupler relay board from the ESP32. The relays draw external 12 V power from the battery. Herein, two relays control the motor's forward and reverse directions. A third relay is also used to execute break movement. When relay 1 is ON, the DC motor runs in the forward direction. The driving wheel and DC motor are coupled here so that the machine will climb the tree. Relay 2 turns on the DC motor to reverse spin it, and the machine will fall. Here, relay three is used to move during the breaks. The break is imposed when the relay is ON and released when it is OFF.

4.5 Flowchart

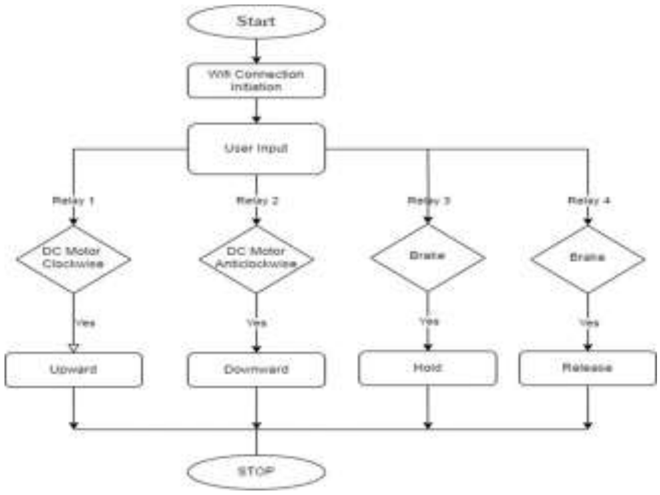

Figure 4. Flowchart

The flowchart for the code depicted in the transmitter is shown in Figure 4. This code creates a WiFi access point and web server on an ESP32 microcontroller, which allows users to manage four relays via the web. At initialization, Wi-Fi settings such as network SSID, password, and IP address information are configured in code. Additionally, relay pins are initialized, and a web server is started at the port. The server handles various URL requests related to controlling the relays, such as turning them on or off. On the other hand, the main loop area of the program allows the server to listen continuously to any incoming client request and update the status of every relay accordingly. Suppose there is a request to turn on or off one relay. In that case, it will call the respective handler function, whose task will be updating that particular relay's status variable and responding to whether it has fulfilled that duty. The `SendHTML()` function generates an HTML page with buttons to control each LED and indicate their current status. This page can be given to clients when connected to the web server, allowing easy interaction with these switches.

4.6 Machine Structure Description

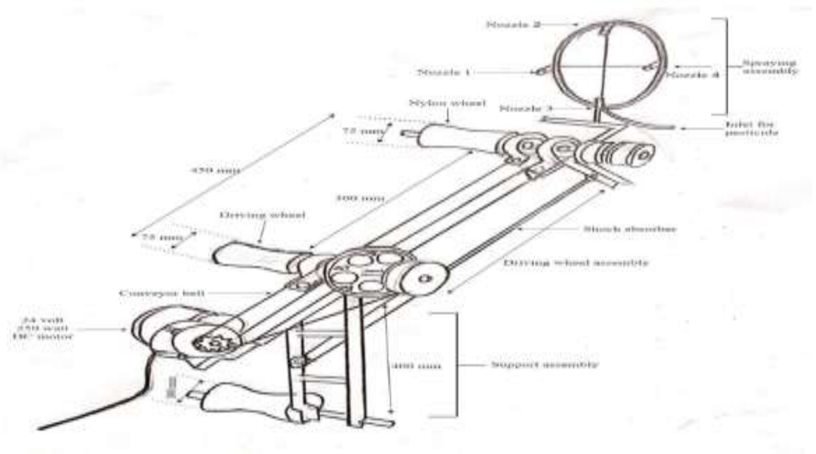

Figure 5 Structural description of the machine

In Figure 5, the structural description of the machine can be viewed. In this setup, using four nozzles in the spraying assembly ensures good coverage of pesticides. The separate inlet for pesticides makes it easier to refill and maintain it. The nylon wheel and driving wheel, of about 75mm, ensure the running is smooth within a distance of 450mm. The conveyor belt further makes the running of wheels smooth, thus enhancing the system's efficiency. A 250-watt, 24V DC motor is powerful enough to drive the assembly effectively. In addition, using an assembly support of 400mm provides stability and structural strength, which is vital in sustaining operation. The shock absorber increases the system's strength against vibration and shocks, lengthening the components' life.

5. Result and Discussion

The time-consuming method of collecting betel nuts was made more accessible by the invention of the betel nut tree climbing machine. Farmers have always had problems climbing these tall trees for a long time, which also comes with risks. The arecanut tree climbing machine allows farmers to ascend and descend quickly using its adjustable grips and straps. It is safe for workers while increasing their productivity. This machine achieves more than just enhancing productivity by decreasing reliance on human labour and reducing accidents. It encourages safer farming practices that improve farmers' livelihoods within a holistic agricultural environment.

Figure 6 Receiver section of the machine

Figure 6 shows a receiver component comprising an ESP32. The ESP32 web server links the transmitter and receiver through a Wi-Fi connection. The receiver receives commands from the transmitter, which initiates motor rotation based on the command signal. An ESP32 is connected to a 5V optocoupler relay, which connects to a 21V power relay. The output from the 12V power relay powers the DC motor and wiper motor.

Figure 7 Side view of the machine

Figure 7 illustrates the side view of the machine, where the main driving wheel is powered by a DC motor and a belt is employed to drive the second wheel. The belt facilitates rotation in both clockwise and counterclockwise directions for the wheels. If the main wheel rotates clockwise, the attached second wheel will rotate counterclockwise.

Figure 8 Top view of the machine

Figure 8 shows the top view of the arecanut tree-climbing machine. The brake is designed using a wiper motor and disk brake. A 12 V power relay controls the breaking operation.

Figure 9 Machine attached to the tree

Figure 9 depicts the machine attached to the tree, utilising a V-shaped chassis to enhance its grip on the tree. The machine can be easily attached and detached and operates effectively even in slippery conditions. It also shows the spraying operation.

Figure 10 Machine on top of the tree

Figure 10 illustrates the machine positioned atop the tree, capable of climbing to the tree's apex autonomously via remote control. The machine is adept at ascending regardless of slight variations in tree diameter and descends cautiously without slipping.

Conclusion and Future Scope

Conclusion

Development of the proposed arecanut tree climbing and pesticide spraying machine addresses a number of issues faced by arecanut farmers, such as labor scarcity, danger, and the issue of spraying pesticide on tall trees. The system incorporates a battery-powered tree climbing facility, a wireless control system based on ESP32, and an automated spraying system that will make pesticide spraying easier and with fewer human efforts.

The remote-control facility will allow the machine operator to operate the machine from a safer place without meeting the pesticide sprayed and avoid the danger involved in climbing the tree. Being lightweight and easily detachable will be an added advantage to the plantation environment where this machine is supposed to be

operated. The braking feature in the machine makes sure that it does not move away when sprayer starts working. The use of a pressure pump and nozzles facilitates the task of spraying pesticide effectively.
In summary, the system developed is a cost-effective solution to pesticide spraying in arecanut plantation.

Future Scope
There are several features that could be added to the system in further research. First, a camera unit could be implemented to enable real-time visual control of the process of spraying and help to detect diseases. Moreover, image processing and artificial intelligence technologies could be used to automatically identify the symptoms of pests and diseases. Furthermore, it would be possible to design a rotating spraying arm to increase the area covered by spraying and help to treat adjacent trees without moving the machine.

Conflict of interest
The author declares that there is no conflict of intrest.

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Data Availability:
This research does not include any types of data

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