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Smart Pesticide Sprayer for Agriculture

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Abstract: *Tree climbing plays an important role in agricultural activities such as pesticide spraying on tall arecanut and coconut trees. This project presents a Tree-Climbing Robot for Pesticide Spraying, designed to reduce physical effort and safety risks associated with manual tree climbing. The robot consists of two gripping segments connected by a threaded rod, which is driven by a high-torque, low-speed DC motor to achieve inchworm-like climbing movement. An ATmega8 microcontroller controls the motors, while L293D motor drivers, a current sensor, contact sensors, and an RF transmitter-receiver system support controlled gripping and remote operation. The robot performs upward and downward movements through coordinated gripping and releasing actions of both segments. This system provides an alternative approach to pesticide spraying on tall trees and aims to improve agricultural safety and reduce dependence on hazardous manual climbing activities. The project contributes to Sustainable Development Goal 8 (SDG 8): Decent Work and Economic Growth.*

Keywords: *Tree-Climbing Robot, Pesticide Spraying, ATmega8 Microcontroller, DC Motors, Threaded Rod Mechanism, RF Remote Control, Arecanut Trees, Coconut Trees.*

I. INTRODUCTION

Tree climbing is an important activity in agriculture, particularly for operations such as pesticide spraying on tall arecanut and coconut trees. However, manual climbing can be difficult and risky, requiring skilled labour and physical effort. The height and varying trunk diameters of trees make these operations more challenging.

Conventional pesticide spraying methods often depend on workers climbing trees manually or using basic climbing equipment. These methods may involve safety risks and require additional time and effort. Therefore, a reliable tree-climbing mechanism is needed to support safer and more convenient agricultural operations.

The proposed system is a tree-climbing robot designed to assist in pesticide spraying on tall trees. It uses two gripping segments connected by a threaded rod to achieve inchworm-like climbing movement. An ATmega8 microcontroller and an RF-based remote-control system support motor operation and controlled movement, aiming to reduce the risks and physical effort associated with manual climbing.

Problem Statement

tall trees for pesticide spraying can be challenging and risky for agricultural workers. Existing methods often requ ire manual effort, skilled labour, and direct climbing, which may increase the risk of falls. Furthermore, variations in tree height and trunk diameter make climbing difficult. Therefore, this project aims to develop a remotely controlled tree-climbing robot that uses a motor-driven gripping mechanism to assist climbing and pesticide spraying on tall arecanut and coconut trees.

Objectives

The main objectives of the tree-climbing robot are: (1) To design and construct a robot for climbing tall arecanut and coconut trees. (2) To develop a gripping mechanism using two segments connected by a threaded rod. (3) To control the climbing movement using DC motors and an ATmega8 microcontroller. (4) To implement an inchworm-like mechanism for upward movement along tree trunks. (5) To use a current sensor and contact sensors to support motor control and gripping operation. (6) To implement RF-based remote control for starting, stopping, and controlling the robot's movement. (7) To integrate pesticide spraying capability into the tree-climbing robot. (8) To test the robot's climbing mechanism, remote operation, and spraying functionality.

Scope

The project focuses on developing a tree-climbing robot for pesticide spraying on tall arecanut and coconut trees. It include a gripping mechanism, threaded rod-based climbing, motor control, and RF remote operation. The web application

displays prediction results and stores historical records. The system aims to reduce manual effort and improve safety during agricultural spraying activities.

II.MATERIAL AND METHODS

Existing System

Conventional tree climbing for pesticide spraying relies mainly on manual climbing methods and basic climbing equipment. These methods require physical effort and skilled workers, while climbing tall trees can increase the risk of falls.

The major limitations addressed by the proposed system are:

- Dependence on manual effort and skilled labour.
- Risk of falls and injuries while climbing tall trees.
- Difficulty climbing trees with varying trunk diameters.
- Need for a reliable gripping mechanism to support climbing.
- Challenges in controlling climbing movement and pesticide spraying safely.

These limitations motivate the development of a remotely controlled tree-climbing robot to assist agricultural workers.

Proposed System

The proposed system develops a tree-climbing robot to assist with pesticide spraying on tall arecanut and coconut trees. The robot uses two gripping segments connected by a threaded rod to achieve inchworm-like climbing movement. The ATmega8 microcontroller controls the DC motors, while the L293D motor driver, current sensor, contact sensors, and RF transmitter-receiver system support gripping, movement, and remote operation.The system aims to reduce manual effort and improve safety during tree climbing and agricultural spraying activities.

System Architecture

The system can be described using three main layers. The control layer uses the ATmega8 microcontroller to control the DC motors and climbing movements. The mechanical layer consists of two gripping segments connected by a threaded rod, which enables the robot to climb the tree. The remote operation layer uses an RF transmitter and receiver to send control commands, while the current sensor and contact sensors support motor and gripping control.

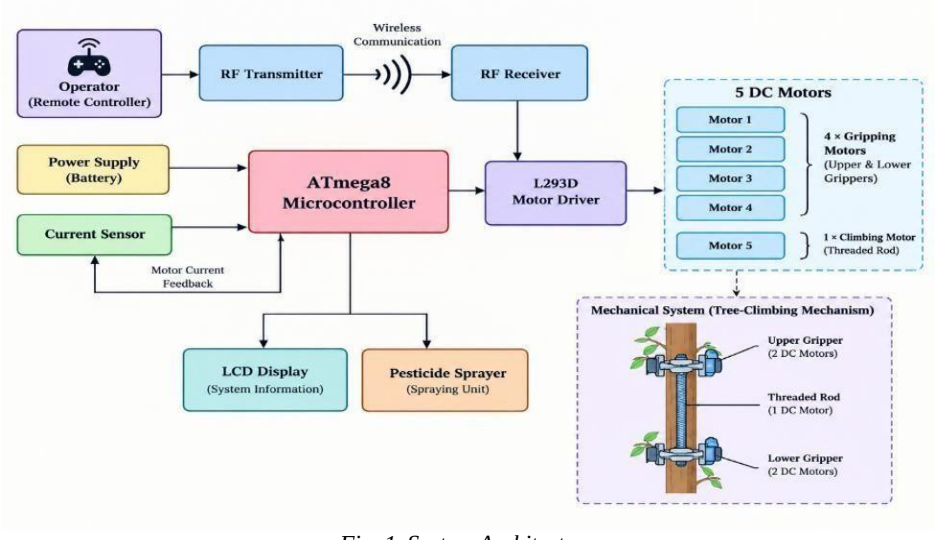


Fig. 1. System Architecture

Technologies Used

Technology	Purpose
Atmega8 Microcontroller	Controls the robot's motor operations and climbing movement.
DC Motors	Operate the gripping legs and threaded rod mechanism.
L293D Motor Driver	Controls the direction and operation of DC motors.
Current Sensor	Monitors motor current to support gripping control.
Contact Sensors	Detect contact during the gripping operation.
RF Transmitter and Receiver	Enables remote control of the robot's movement.
Embedded C	Used for programming the microcontroller.
Proteus Design Tool	Used for circuit design and simulation.

Implemented Modules

- **Remote Control Module:** Enables the user to control the robot's movement using an RF transmitter and receiver.
- **Motor Control Module:** Controls the DC motors through the ATmega8 microcontroller and L293D motor driver.
- **Tree-Gripping Module:** Uses gripping legs with pointed feet to hold the tree trunk securely.

- **Climbing Mechanism Module:** Uses two segments connected by a threaded rod to produce inchworm-like climbing movement.
- **Current Monitoring Module:** Monitors motor current using a current sensor to support gripping control and help prevent motor stalling.
- **Contact Detection Module:** Uses push-button contact sensors to support the gripping operation.
- **Pesticide Spraying Module:** Supports the intended application of pesticide spraying on tall trees.
- **Display Module:** Uses an LCD display to show system information.

Testing Methodology

The tree-climbing robot is evaluated through testing of its mechanical movement and electronic control functions. Testing includes checking the gripping operation of the upper and lower segments, clockwise and anticlockwise rotation of the threaded rod, upward and downward climbing movements, and RF remote-control operation. The current sensor is checked to monitor motor current and support gripping control, while the start and stop switches are tested to control gripping and release.

III.RESULTS

Functional Testing

The tree-climbing robot is tested through a set of functional test cases covering upper and lower segment gripping, threaded rod operation, upward and downward climbing movements, DC motor control, RF remote operation, and current sensor functionality. The tests are intended to verify the robot's gripping mechanism, climbing movement, and remote-control operation.

Test ID	Scenario	Expected outcome	Actual result
TC01	Upper Segment Gripping	Upper segment grips the tree trunk securely.	verified
TC02	Lower Segment Gripping	Lower segment grips the tree trunk securely.	verified
TC03	Upper Segment Release	Upper segment releases the tree trunk when required.	verified
TC04	Lower Segment Release	Lower segment releases the tree trunk when required.	verified
TC05	Threaded Rod Operation	Threaded rod rotates to contract and extend the two segments.	verified
TC06	Upward Climbing Movement	Robot moves upward using the inchworm-like climbing mechanism.	verified
TC07	Downward Climbing Movement	Robot performs the downward movement through motor control.	verified
TC08	DC Motor Control	DC motors operate according to the control commands.	verified
TC09	RF Remote Operation	Robot responds to remote-control commands.	verified
TC10	Start and Stop Control	Robot starts and stops according to the control switches.	verified
TC11	Current Sensor Monitoring	Motor current is monitored during the gripping operation.	verified
TC12	Contact Sensor Operation	Contact sensors support the gripping and release operation.	verified
TC13	Climbing Structure Test	Robot's climbing operation is evaluated on natural and man-made structures.	verified

Table I. Representative functional test cases

Results Summary

The final testing results of the Tree Climbing Robot should include the total number of test cases executed, passed, failed, and retested, where applicable. Testing should cover the gripping mechanism, upward and downward movement, coordination between the upper and lower segments, threaded rod operation, RF-based remote control, motor functioning, and pesticide spraying mechanism. The robot's climbing stability, gripping performance, and ability to move along the tree should also be evaluated under actual testing conditions. The pass rate should be calculated using the formula: Pass Rate = (Number of Passed Test Cases / Number of Executed Test Cases) × 100. The verified test counts and calculated pass rate should be reported only after the test cases have been executed and their outcomes documented.

Observed Application Functionality

The implemented Tree Climbing Robot provides automated tree climbing through its upper and lower gripping mechanisms, threaded rod-based movement, DC motor operation, and RF-based remote control. The robot supports upward and downward movement by coordinating the gripping and releasing actions of both segments. Insert actual photographs of the complete robot prototype, upper and lower gripping mechanisms, threaded rod arrangement, RF transmitter and receiver, motor driver circuit, climbing operation on a tree, and pesticide spraying mechanism. Include only photographs of components and operations available in the constructed robot, and ensure that the images clearly demonstrate the actual hardware testing.

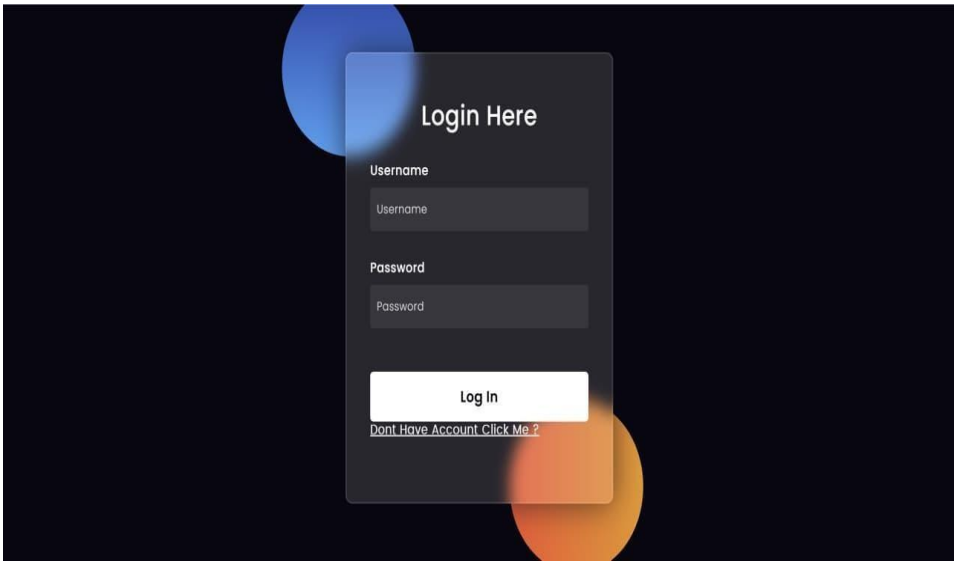


Fig. 1. Login Interface



Fig. 2. Areca Nut Disease Prediction & Get Cure Interface

IV.DISCUSSION

The Tree Climbing Robot integrates a mechanical gripping mechanism with a threaded rod-based climbing system to achieve vertical movement on coconut and arecanut trees. The upper and lower gripping segments work alternately, while DC motors and the ATmega8 microcontroller control the climbing mechanism. RF communication enables remote operation of the robot.

The inchworm-inspired movement allows the robot to climb by gripping, releasing, and moving its two segments in sequence. This mechanism provides an alternative to manual tree climbing for pesticide spraying activities and helps reduce the risks associated with climbing tall trees.

The performance of the robot depends on gripping strength, tree diameter, motor torque, stability, and proper coordination between the segments. Further improvements in the mechanical structure, control system, and spraying mechanism can enhance its efficiency and reliability in agricultural applications.

V.CONCLUSION

The Design and Construction of a Tree Climbing Robot for Spraying Pesticide is a project developed to reduce the risks and difficulties involved in manual tree climbing. The robot uses an inchworm-inspired climbing mechanism with upper and lower gripping segments, a threaded rod, DC motors, and an ATmega8 microcontroller to achieve vertical movement. RF-based remote control is used to operate the robot's climbing movements.

The project demonstrates an alternative approach to climbing coconut and arecanut trees for pesticide spraying activities. The constructed robot has been tested to evaluate its climbing mechanism and operation. Further improvements in gripping stability, movement control, and the spraying mechanism can enhance its performance and reliability for agricultural applications.

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