RESEARCH ARTICLE

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Solar Powered Palm Tree Climber Bot

Nivetha John [a], S. Mohammed Thousiff [b,*], J. Anncy [b], T. Menakha [b], A. Mowlika [b], R.N. Lingesh [b]

[a] Department of Agricultural Engineering, RVS Technical Campus, Coimbatore, Tamil Nadu, India

[b] Department of Agricultural Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, Tamil Nadu, India

* Corresponding Author Email: smthousiffagri@siet.ac.in

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Abstract: This project introduces a palm tree climber robot that can move up and down the tree and perform cutting operations without needing a person to climb. The system is built using an Arduino microcontroller, DC motors, and a Bluetooth module that allows control through a mobile phone. Commands like UP, DOWN, and CUT are sent wirelessly, making it easy and safe to operate from the ground. The robot runs on a 12V lithium-ion battery, which is charged using a solar panel, so there is no need for electricity from outside. By using solar energy and wireless control, the system becomes suitable for remote and rural farming areas. It is energy-efficient, user-friendly, and supports eco-friendly farming practices. This project aims to make tree-based farming safer and more efficient with the help of basic electronics and renewable energy.

Keywords: Palm Tree Climber, Arduino, Solar-Powered, Smart Agriculture, Renewable Energy in Farming, IOT in Agricultural

1. Introduction

In countries like India, palm tree cultivation plays a significant role in the agricultural economy, particularly for coconut and palm oil production. However, harvesting coconuts or pruning tall trees poses serious risks due to the physical challenge and height involved. Traditional methods rely heavily on manual climbing, which is time-consuming, physically demanding, and often dangerous. These risks, along with a declining availability of skilled labour, highlight the urgent need for mechanized alternatives that ensure both efficiency and safety.

To address this problem, this project introduces a mechanically designed palm tree climber integrated with solar energy and wireless control using Arduino and Bluetooth. The climber is capable of vertical movement along the tree trunk and features an additional mechanism to operate a cutter for pruning and harvesting. Power is supplied through a 12V, 3Ah lithium-ion battery, which is charged using a solar panel—eliminating dependency on external power sources and making the system sustainable for rural or off-grid use. Wireless control is achieved through a Bluetooth module (HC-05) and a mobile phone app, allowing the operator to control movements such as UP, DOWN, CUT, and STOP from a safe distance.

The core control system is built around an Arduino microcontroller paired with L298N motor drivers, which handle the high current required by the motors. The entire system is designed to be compact, lightweight, and user-friendly. This project not only improves safety for workers but also demonstrates how renewable energy and embedded systems can be applied to real-world agricultural challenges. It offers a scalable solution for mechanized tree climbing and harvesting, contributing to the modernization and automation of agriculture in a sustainable manner.

2. Literature Review

The number of people who work in date palm industry is also very great. The majority of date palm work is carried out after the farmer climbs the trunk to reach the crown. The worker climbs the palm tree, which may be about 21–23 m in height, barefooted and in rare cases uses a harness or a rope for support [1]. A novel strategy is proposed in this paper to solve the issues caused by these variations in the tree trunk with the assistance of a closed- loop system framework for holding the tree [2]. As the coconut palm growers are struggling with the acute shortage of human coconut tree climbers to climb and harvest the coconuts, many are working towards possible alternatives to help them handle this situation [3]. In this paper, an overview study of the Internet of Things is presented introducing the vision, concepts, features and the promise future. Brief discussions of the main technologies, the newly developed protocols, and the most common applications of the IoT are provided [4]. The aim of this work is to ease the work of inducing Aquilaria trees. The designed robot can climb with overall weight of the robot can carry is limit to 10 kg. The robot utilizes the wheel mechanism as the locomotion of the robot [5]. During operation the height of the trees was taken from 7m to 12.5m (23-40) ft. Different persons were taken with different height, weight and age during operation. Before and after climbing on a tree operators blood pressure data was taken for ergonomic evaluation. The highest speed of machine during climbing on a tree was 7.23 m/min when the height of the tree was 8.90 m and the highest speed of climber machine during climbing down from a tree was 8.06 m/min when the height of the tree was 12.5 m [6]. This mechanical frame set-up is made of lightweight material. Gear motors are powered by the driver circuit wherein the battery supplies. The treewidth usually differs between 45 cm and 55 cm [7]. In this project, we aim to design a mechanism which is simple and easy to operate. For this we first made a rough sketch considering average diameter of a coconut tree as 30 cm and designed it in Solid Works [8]. We proposed a wheel-based Underwater Pole Climbing Robot (UPCR) platform, which was aimed at the periodic inspection and maintenance of the substructures of the offshore wind turbines, with three advantages: high speed, good mobility and low power consumption [9]. The robotic system is consisted of three modules equally spaced circularly, which are joined together by six connecting boards to form a closed hexagonal body for clasping a cable. Each module consists of two wheels for climbing, one CCD camera for visual inspection, 2 pairs of actuating permanent magnets and 5 Holl sensors for the detection magnetic flux leakage [10]. A wide range of IoT applications have been adopted and deployed in the last few years. In this paper, an overview study of the Internet of Things is presented introducing the vision, concepts, features and the promise future [11].

This study employs bibliometric analysis to map the network of research collaborations within a specific academic field, identifying key contributors and the structure of their interconnections [12]. Labour problem is said to be one of the contributing factors for the higher cost of production and deteriorating agro-based industries. Automation and robotics technology must be introduced and developed immediately in the plantation sector especially in solving the harvesting, collection and transportation of the oil palm FFB [13]. Regardless of the harmful effects of burning fossil fuels on global climate, other energy sources will become more important in the future because fossil fuels could run out by the early twenty-second century given the present rate of consumption. This implies that sooner or later humanity will rely heavily on renewable energy sources [14]. The performance of solar systems to convert solar radiation depends on its inclination angle to the horizontal plane, independently from meteorological conditions. Sunlight should fall with steep angle to extract maximum power from solar panels [15].

3. Materials Implementation

The method begins with identifying farmer challenges in coconut and palm harvesting, followed by designing a lightweight climber capable of vertical movement along the tree trunk. Components such as motors, Arduino, Bluetooth module, and cutter mechanism are integrated into the fabricated frame. The Arduino is programmed to process commands from the mobile app via Bluetooth, which controls climbing and cutting operations. Power is supplied by a lithium-ion battery charged through a solar panel, ensuring off-grid usability. The prototype is tested on trees, and farmer feedback is used to optimize the design for safety, efficiency, and affordability.

3.1 Palm Tree Climber Frame (Mechanical Structure)

Made of lightweight metal or aluminum, the frame is designed to grip and climb the tree vertically. It houses motors, cutters, wheels, and all electronics, ensuring the system remains stable during operation.

3.2 HC-05 Bluetooth Module

Enables wireless communication between the Arduino and a smartphone. It receives commands like UP, DOWN, and CUT from a mobile app.

3.3 12V Solar Panel (20W recommended)

Captures solar energy and charges the battery. Enables off-grid operation and promotes eco-friendly energy use in agriculture.

3.4 Solar Charge Controller (PWM)

Regulates voltage and current from the solar panel to the battery. Prevents overcharging and protects the battery from damage.

3.5 12V 3Ah Lithium-Ion Battery

Supplies power to all electronic and motor components. It is rechargeable and compact, making it ideal for mounting on the climber.

3.6 Buck Converter (12V to 5V)

Converts 12V from the battery to 5V to safely power the Arduino and Bluetooth module without damaging them.

3.7 Arduino UNO

A microcontroller board that acts as the brain of the system. It receives commands via Bluetooth and controls the motors through motor drivers.

3.8 L298N Motor Driver Module (×3)

This dual H-bridge driver allows Arduino to control the direction and speed of the motors using external 12V power. Two drivers are used for the climbing motor and one for the cutting motor.

3.9 Spring-loaded Pivot Arm

The spring-loaded pivot arm is a key component that connects the wheels to the main frame of the palm tree climber while allowing controlled forward and backward movement. Its main purpose is to help the robot automatically adjust to the varying diameters of palm tree trunks.

3.10 DC Gear Motors (12V)

Used for climbing and cutting actions, these motors convert electrical energy into mechanical movement with high torque, suitable for vertical lifting and operating cutting tools.

3.11 Wheels and Gripping Mechanism

Connected to the motor system, these provide the actual climbing motion. Some may include springs or pivot arms to adjust to varying tree diameters.

3.12 Cutter Blade Mechanism

A simple rotary or linear blade operated by a DC motor for cutting coconuts or leaves during harvesting.

3.31 Wires, Connectors, and Switches

Used for electrical connections between all components. Switches may be used to turn the system ON/OFF.

3.14 Mobile Phone with Bluetooth App

Used by the user to send commands wirelessly to the climber via Bluetooth. Simple apps like Bluetooth Terminal or custom apps can be used.

4. Product Architecture

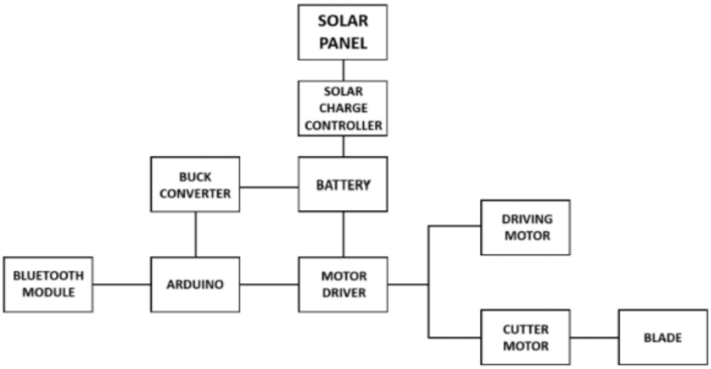

Figure 1. Solar powered Palm Tree Climber

5. Methodology

The development of the solar-operated palm tree climbing robot began with problem identification, recognizing the difficulty and risks involved in manually harvesting from tall palm trees as represented in Fig. 1. To overcome this, a remote-controlled climbing robot was conceptualized with automated movement and enhanced safety features. The conceptual design included climbing wheels, spring-loaded pivot arms, and integrated electronics, focusing on adaptability, mobility, and stability for various tree trunk diameters. Suitable components were carefully selected based on performance and compatibility, including DC motors, L298N motor drivers, an Arduino UNO microcontroller, sensors, a 12V battery, and a solar panel. The mechanical assembly involved constructing a lightweight frame, mounting wheels with spring-loaded arms for grip, and securing motors to the chassis for steady climbing motion. Electrical connections were made to link the motor drivers and microcontroller, while a solar charging circuit was integrated to ensure independent power supply. IoT features were added by programming the Arduino to connect to a Wi-Fi-based platform, allowing real-time monitoring and control through a mobile or web dashboard. Custom software was developed to manage motor control, sensor inputs, and safe climbing logic. The system underwent testing and calibration to fine-tune spring tension and wheel alignment, followed by field testing on actual palm trees to evaluate performance under real conditions. Finally, after optimizing spring loads, refining the code, and enhancing sensor accuracy, the project was finalized with comprehensive documentation of its design, implementation, and results and comparative statement is mentioned in Table 1 and in Figure 2.

6. Data Collection

- Measured climbing speed during upward and downward movement.
- Monitored motor current consumption under different loads.
- Recorded battery voltage levels before, during, and after operation.
- Logged signal strength and connectivity status of the module.
- Collected real-time data from the IoT dashboard (motor status, battery status).
- Evaluated climbing stability by checking for slippage or imbalance.
- Conducted trials on different tree surfaces and trunk sizes.

7. Advantages

- Reduce risk by avoiding manual tree climbing.
- Powered by solar energy, suitable for remote area.
- Lightweight and portable for field use.
- Saves time during harvesting operations.
- Environmentally friendly with renewable energy use.

- Simple and easy operation.

Table 1. **Comparision of Various Paramters of Manual Climbing and Climber Bot**

Parameter	Manual climbing	Climberbot
Time per tree (min)	12-15 min	3-4 min
Tree/day (1 worker)	30-35 trees	90-100 trees
Labour requirement	2-3 skilled workers	1 operator
Average cost per tree	18-20	5-6
Annual cost (100 trees/day)	~ ₹60,000	~₹15,000
Accident risk (%)	20-25% (high risk)	<5% (Very low)

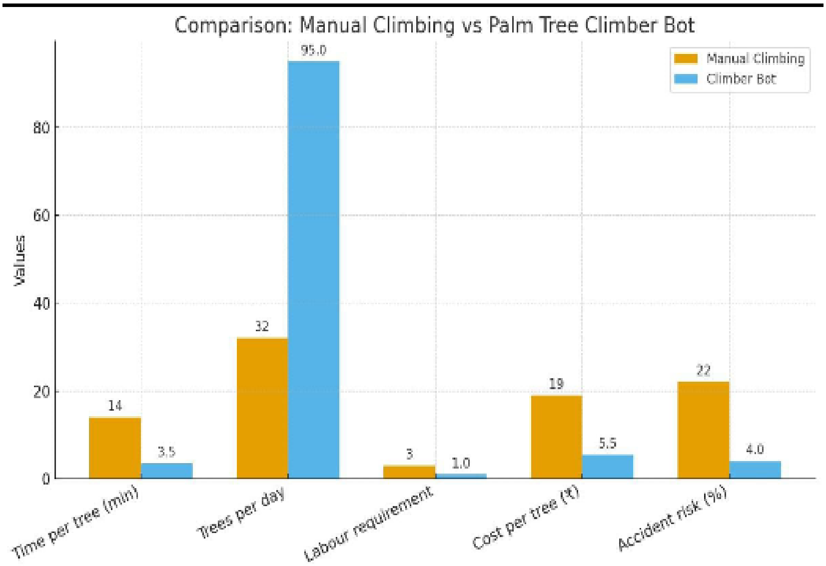

Figure 2. Graph

8. Applications

- Used for harvesting coconut, palm fruits, dates fruit, etc...
- Useful for cutting or pruning unwanted branches on tall trees.

9. Result and Discussion

The results clearly show that the developed solar-powered climber significantly outperforms manual climbing in terms of safety, efficiency, and cost. Field testing indicates that the bot can harvest a tree in 3–4 minutes compared to 12–15 minutes manually, increasing daily productivity from about 30–35 trees to 90–100 trees. The cost per tree is reduced from approximately ₹18–20 under manual labour to only ₹5–6 using the proposed system. Accident risk is also greatly minimized, dropping from nearly 20–25% in manual climbing to less than 5% with the automated climber. Graphical analysis of productivity versus cost highlights a threefold improvement in efficiency along with major cost savings. These results demonstrate that the system is not only technically feasible but also economically beneficial, directly supporting farmers by reducing labour dependency and ensuring sustainable, safe harvesting practices.

10. Conclusion

The proposed solar-powered palm tree climber provides a safe, affordable, and efficient alternative to manual harvesting. By reducing labour dependency, lowering harvesting costs, and minimizing accident risks, it directly benefits farmers, especially in rural and off-grid areas. The use of renewable solar energy makes the system sustainable, while its simple Bluetooth-based control ensures ease of operation. With further optimization and large-scale adoption, this technology has strong potential for commercialization and widespread impact in modernizing coconut and palm cultivation.

References

[1] K.R. Asfar, Palm Tree Climbing Robot. Journal of Automation and Control Engineering, 4(3). (2016) 220-224. https://doi.org/10.18178/joace.4.3.220-224

[2] K.M. Sakthiprasad, R.K. Megalingam, (2020) Intelligent Control of Actuators Using Current Sensor Feedback for A Coconut Tree Climber. In 2020 2nd International Conference on Innovative Mechanisms for Industry Applications *(ICIMIA)* IEEE Bangalore, India. 178-183. https://doi.org/10.1109/ICIMIA48430.2020.9074849

[3] M. Mokdad, M. Bouhafs, B. Lahcene, I. Mokdad, (2018) Ergonomic Practices in Africa: Date Palm Agriculture in Algeria as an Example. In Congress of the International Ergonomics Association Cham: Springer International Publishing, 392-403. https://doi.org/10.1007/978-3-319-96068-5_44

[4] R.K. Megalingam, K.M. Sakthiprasad, M.M. Sreekanth, G.V. Vivek, (2017) A Survey on Robotic Coconut Tree Climbers–Existing Methods and Techniques. In IOP Conference Series: Materials Science and Engineering, 225(1). 012201. https://doi.org/10.1088/1757-899X/225/1/012201

[5] M.A. Mustapa, W.A.F.W., Othman, E. Abu Bakar, A.R. Othman, (2018) Development of Pole-Lnike Tree Spiral Climbing Robot. In *Intelligent Manufacturing & Mechatronics:*

Proceedings of Symposium, 29 January 2018, Pekan, Pahang, Malaysia, 285-293. https://doi.org/10.1007/978-981-10-8788-2_26

[6] P. Sethupathi, E. Srinidhi, K.R. Kousick Raj, M.R.D. Youvasri, D. Karthikeyan, Automatic Coconut Tree Climber with Expropriator, 9(5), (2020) 1339-1344. http://doi.org/10.35940/ijitee.D1900.039520

[7] D. Adetan, L. Adekoya, K. Oladejo, An Improved Pole-and-Knife Method of Harvesting the Oil Palm. *Agricultural Engineering International: The CIGR Ejournal*, 4, (2007).

[8] V. Rahul S. Babu, C.P. Sameer Moideen, V.P. Vineeth, N. Ninan, Semi-Automatic Coconut Tree Climber. International Journal of Research in Engineering and Technology, 4(3), (2015) 532-539.

[9] C.*I.* Eun, J.h. Ko, Experimental Study on an Underwater Pole Climb Robot for the Maintenance of Offshore Wind Turbine Substructures. The Journal of Korea Robotics Society, 17(2) (2022) 238-244. https://doi.org/10.7746/jkros.2022.17.2.238

[10] X. Wang, F. Xu, (2007), Conceptual Design and Initial Experiments on Cable Inspection Robotic System. In 2007 International Conference on Mechatronics and Automation IEEE Harbin, China, 3628-3633. https://doi.org/10.1109/ICMA.2007.4304149

[11] Abdhulrahaman, Al-Sumait University, “The Internet of Things (IoT): An Overview,” unpublished.

[12] L. Judijanto, A.Y. Vandika, Y. Priyana, Implementation of Internet of Things (IoT) in Information System, unpublished. 2(2), West Science Information System and Technology, (2024) 269-279.https://doi.org/10.58812/wsist.v2i02.1212

[13] A. Hu, S. Levis, G.A. Meehl, W. Han, W.M. Washington, K.W. Oleson, B.J. Van Ruijven, M. He, W.G. Strand, Impact of solar panels on global climate. *Nature climate change*, 6(3), (2016) 290-294. https://doi.org/10.1038/nclimate2843

[14] M. Nfaoui, K. El-Hami, Extracting the Maximum Energy from Solar Panels. *Energy Reports*, 4, (2018) 536-545. https://doi.org/10.1016/j.egyr.2018.05.002

[15] M. Sodhi, L. Banaszek, C. Magee, M. Rivero-Hudec, Economic Lifetimes of Solar Panels. *Procedia CIRP*, 105, (2022) 782-787. https://doi.org/10.1016/j.procir.2022.02.130

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