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Design and Fabrication of Coconut Tree Climbing and Harvesting Machine

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Abstract*: This paper focuses on designing a low cost coconut tree climbing and harvesting robot. The device consists of a triangular base frame which supports all the components to be built upon. It is fitted with three DC motors - nylon tyres with rubber grippers at 120 degrees each other for ease of the operations. A specially designed remote controlled cutting unit is mounted on the frame. DC geared motors having reduction gears which ensures self-locking of the tyres and thus maintains the height. To accommodate for change in the diameter of coconut tree as the device moves up and down, a spring loaded mechanism is used for exerting sufficient tension required for gripping the tree. The device has been tested for its performance and found safe, reliable, and efficient and also reduces the problems in climbing tree and cutting coconut to a good extent.

Keywords: Coconut Tree, diamond shaped body, spring sliding mechanism, Cutter arm

I. INTRODUCTION

Researchers all around the world work on developing climbing machines, most of these climbing machines are capable of climbing regular structures like poles, walls etc. But a very few are capable of climbing trees, main reason being irregular surface and variation of diameter with length. It also requires greater agility and high manoeuvrability to be used as a product. Also the bark of some trees may not be strong enough to bear the weight of the climbing device, hence conventional climbing machine cannot be used for tree climbing applications. Many trees like coconut tree, arecanut tree, and palm trees are so tall that climbing them becomes risky. Hence harvesting fruits and nuts and maintaining them becomes difficult. So development of a unique tree climbing mechanism is necessary which may be used for maintaining and harvesting applications. In recent years, labour scarcity has emerged as one of the foremost challenges in farming. One crop that has been most affected by this is the coconut. Coconut trees attain a height of about 60-70 feet. It is mandatory to climb the trees a minimum of five times a year for a successful harvest - twice for the preventive spray against fungal disease, and thrice to harvest the coconut. Only skilled labourers can carry out these farming operations. They have to climb the trees using muscle power. As this involves real hard, physical exertion, younger generations of labourers are losing interest, with potentially harsh implications for coconut cultivation. The spraying is done in monsoon, while harvest time is typically in summer. The scope of this project is limited to climb coconut trees having diameter between 220 and 320 mm. Therefore, maintaining sufficient friction force capable of handling the self-weight, maintaining the stability of the structure while in motion, reducing the total weight, and achieving the precise gripping are the important parameters that have to be considered. The machine should be capable of adjusting to the varying cross-section of the tree during upward and downward movements. The machine should grab the tree firmly to maintain its positions during the operation. The geared motor should be powerful enough to carry the payloads and weight of the machine. In this study, considering all the above parameters, a safe, reliable and efficient climbing and spraying machine is designed and fabricated.

II. LITERATURE REVIEW

Mani A, Jothilingam A [1] discussed about the development and fabrication of a tree climber and harvester. It consists of two mechanisms. One for climbing and another for harvesting. They designed an octagon shaped chassis where wheels at specific intervals were provided.

The proposed design by Mani and Jothilingam had the location of centre of mass of the device outside the tree and it fused both spiral and straight climbs. An arm was provided in order to fulfil the harvesting requirement. The bunch of nuts is located by a camera which is fixated to the arm. The cutting is done by a saw after a clear view of the nuts is obtained. The entire mechanism was controlled by remote control. They discussed about the hardware setup and controlling units were designed.

Salice Peter, Jayanth M, Arun Babu M.K , Ashida P.V, Akhil K.T [6] focused on designing a tree climbing robot. There prime consideration in designing tree climbing robot is of the motion planning and method of gripping. The design has arms involving four legs and sharp end as feet. The mechanical structure is designed to move the structure upwards against the gravitational forces in

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successive upper body and lower body movements similar to a tree climber. The gripping is designed in a way to dig the upper or lower part of the structure in to the tree facilitating the upward movement. The result shows that it can successfully climb the trees. Tree climbing robot has the potential to be applied to various pursuits, such as harvesting, tree maintenance, and observation of tree dwelling animals.

III. METHODOLOGY

The various steps involved in the project were as follows:

A. To study the shape and size of the tree to design a suitable device.
B. To develop a suitable mechanical model to surround the tree and climb smoothly.
C. To select the desired material which suits needs like less weight and less cost.
D. Selecting the desired components such as wheels and motors.
E. To attach an arm with minimum degree of freedom and to attach a rotary blade for an end effector.

IV. DESIGN

According to the study, there can be two types of motion for tree climbing, one is discrete and other is continuous motion. In discrete motion however it provides strong grip the motion is executed step by step whereas in continuous motion the motion is executed without any stop. So, we used continuous motion for tree climbing.

A. Construction

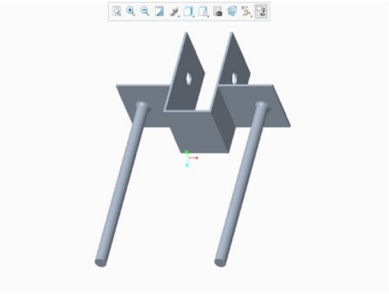
1) Body: Body frame consist of one base plate and three side plates. The base plate is designed in the form of diamond shape with six sides. The three side plates are welded on three equidistant sides of the plate. The purpose of using the side plates is to attach the frame carrying climbing wheels .Each side plate are also drilled with two holes with specific centre to centre distance. The holes are provided for sliding motion of the spring guiding mechanism. For clamping the body around the trunk, it is divided into three sections and hinged at two ends for easy opening as shown in figure below and on the opposite side of the hinged portion the frame is locked with the help of the lock nuts.

Material used- Mild Steel.



2) Wheel Frame: A u-shaped clamp is used to hold the tyre with the provision for attaching DC motor. Rods were used to fix thee clamp to the frame. Springs were used in the rods so that the frame can adjust to the variation in diameter of the coconut tree trunk. The dimensions of the clamp were determined relating to size of the tyre and motor

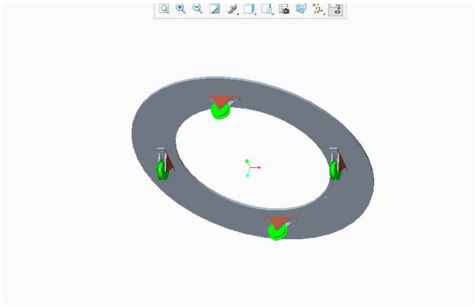
Material used- Aluminium.



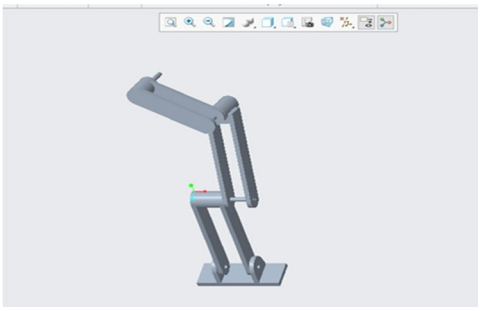
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3) *Turning Plate:* It is the circular plate which forms the base for the robotic arm. The plate is placed on the guide profile with the support of nylon wheels. Turning plate is used so that all the cutting work is carried out at once when the robot reaches the top. Turning plate is cut into two equal halves and clamped around the trunk with the help of lock nuts. The plate is made slide with the help of a tyre driven by a DC motor attached vertically to it.

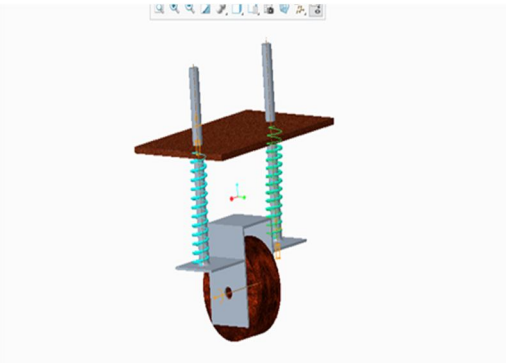
Material used- Mild Steel.



4) *Robotic Cutter Arm:* The robotic arm is mounted on the turning plate consists of three linkages each driven by servo motors, linkages are made of aluminium sheet of thickness 5mm.On the top link of arm, cutter is mounted which is driven by D.C. motor having 15000 rpm. The arm linear movement is designed to be able to reach the coconut. The concept of cutter arm without cutter arm has been shown in the figure.



5) *Spring and Slider Mechanism:* Each wheel has an auto-fastening mechanism using a spring which serves as a suspension. The spring which is mounted on the rod parallel to surface of body plate and slider, operated by pushing the slider to the inside so as to sufficiently grab the trunk and adjust to varying tree trunk diameter. The length of the spring for the maximum pressure is 50 mm, whereas under unpressed conditions is 120 mm, this is because of the limited expansion length of a slider. Slider maintains the position of the wheels to be remain perpendicular to the supporting side of the robot body and also as a way of translational movement mechanism when the wheel adjust to the tree diameter. Slider is designed with stainless steel material and has expansion capabilities up to 150 mm so that when all of the sliders fully suppressed, tree trunks diameter can reach up to 320 mm.



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6) Electronic Components and other Parts

a) Three driving wheels are used, which are actually White Double Screw Mount Tyre and having Diameter of 70mm

b) Three geared DC motor is to drive wheel. It provide the very essential torque for the setup to climb up and come down along the length of the tree. It is having a torque of 45 kg-cm and speed of 50rpm.

c) One more DC motor of 15000rpm is used for driving the cutter blade.

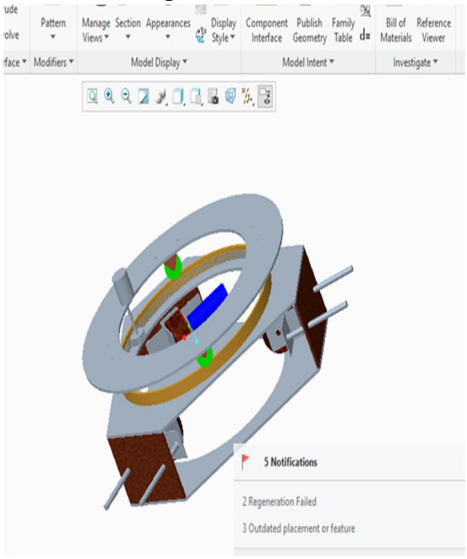
d) Spring is selected based on calculations done. It is having a free length of 120mm.

e) For controlling the cutter arm, servo motors are used, specified as PDI 6255MG and having torque of 25 kgf cm.

f) For complete control over the machine wireless remote control is used, named as Fly Sky FS-CT6B 6-Channel 2.4 Ghz Transmitter and

Receiver.

The complete CAD model without cutter arm is shown in figure below.



B. Working

Firstly, the body frame is opened and attached around the tree using locking nut. Spring is compressed in its initial position and body frame adjust to the diameter of the tree. The robot moves up with the aid of tyre powered by DC motors. For the machine, to stay still at its position at the top of the tree, worm geared motor is installed. Once the robot reaches the top, the cutter starts working. The turning plate moves in an arc, cutting down the coconut bunch from the side on point where it attaches to the tree. Location of the bunch is identified with the help of wireless camera installed with the cutter arm. After cutting, the bunches, the robot is then brought down. The whole

Control is done by wireless remote.



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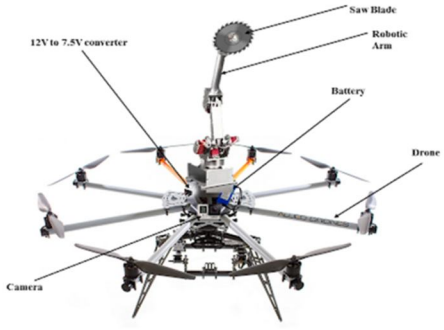
Estimated time for climbing is “60 seconds”.

V. FUTURE WORK

In future we intend to increase the degrees of freedom of the robotic arms by implanting more stepper or servo motors and equip the robotic arm with sensors to detect whether the coconuts are ripe or not. By making the robot autonomous in detecting ripe coconuts, the controller on the ground, will have to only focus in manoeuvring the robot on the coconut tree.

Also, the material for body frame can be replaced with Aluminium composites or Nano fibres which are stronger and lighter than M.S. The project can be made more efficient by inclusion of pesticide sprayer.

In future the machine can also be replaced with drone with above mentioned features as shown in the figure.



VI. CONCLUSION

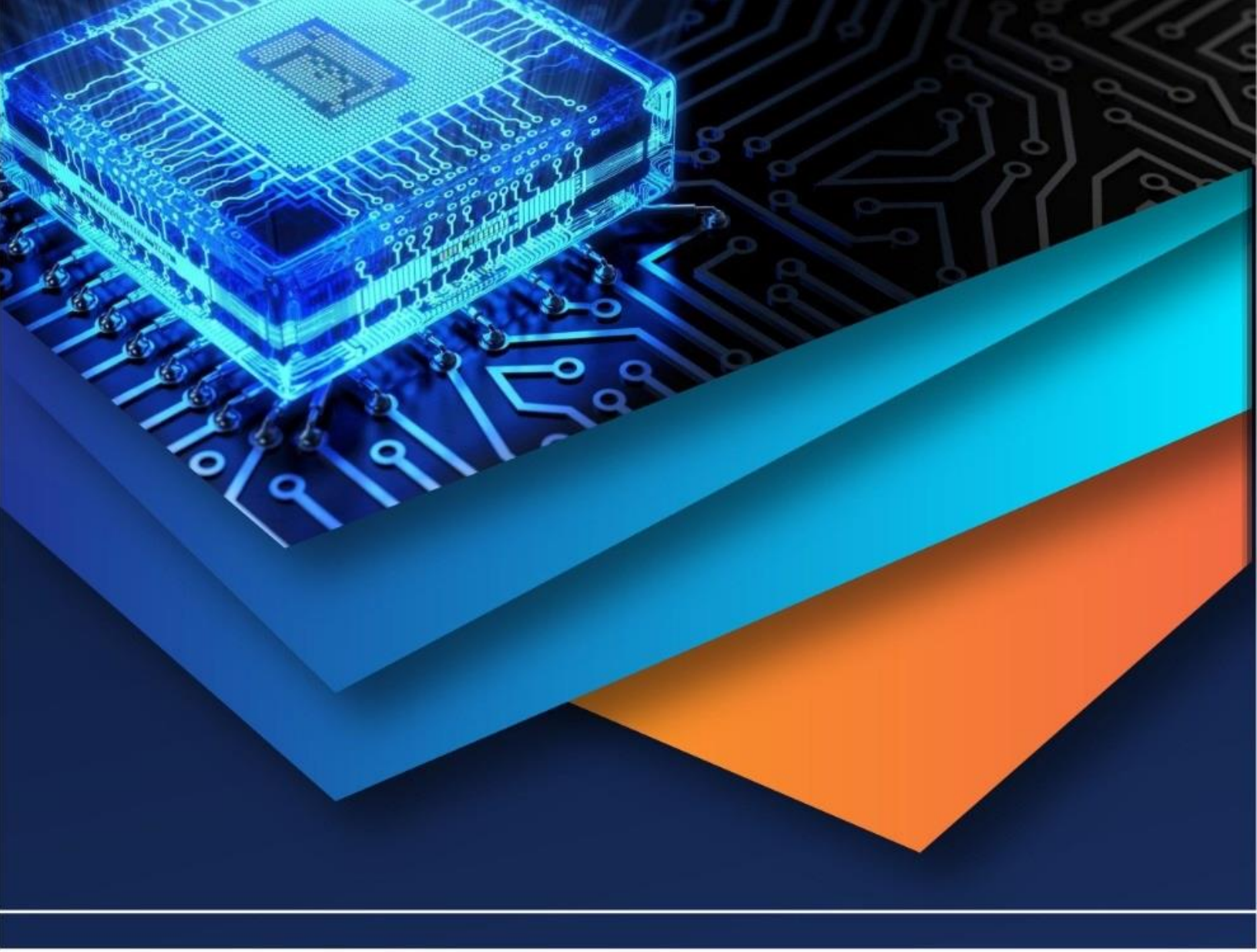
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A novel method for coconut tree climbing and harvesting is proposed. In present day system, palm tree harvesting is still done with manpower involvement without proper safety measures which can lead to serious casualties. It is not economical and also very time consuming. This project is intended to reduce human efforts for palm tree harvesting. It can be controlled using PC or any android devices which makes the control easier and user friendly. This is a onetime investment so that it is economical. Since it is a wireless design the control and working will be easier when compared to already existing systems

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