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Semi - Automatic Areca Nut Tree Climbing and Harvesting Robot

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Abstract: Sourcing skilled labor for agriculture sector has become a tedious job in today's time. There is a need for mechanization in the farming process in order to cope with lack of manpower. Kerala, despite being the second largest producer of areca nut in India, depend on conventional climbing techniques which involve high risk for harvesting areca nut. This project is an intuitive mechanized robot, which would eliminate the need of manual climbing for harvesting areca nut. The main goal of the system is the use of economical technology which is safe and can be easily implemented. The robot consists of two mechanisms, climbing mechanism and cutting mechanism. The robot is so simple that it can be controlled by anyone.

I. Introduction

Areca nut is an erect unbranched palm reaching heights of 10-30 m, depending upon the environmental conditions. It thrives in areas of high rainfall. Majority of areca nut is harvested by climbing the tree and cutting the nuts down by hand. This process may seem simple; however, it is actually quite dangerous.

Areca nut and the palm as a whole is used widely in India as a masticator for chewing purposes, vegetable, medicine, stimulant, timber, fuel wood, clothing and so forth. Kerala, account for about 70 percent of India's areca nut production. Usually all over the country, farmers practice conventional harvesting method in which areca nut are picked by specially trained skillful and experienced climbers. Due to the height and lack of branches, the difficulty and risk involved in climbing is high. Due to the risks involved, few people are attracted to this profession which tend the skilled climbers to increase their wages.

The scarcity in climbers results in disruption of harvesting cycles leading to losses for the growers. As against the general norms of harvesting cycles, growers are only able to cultivate depending on the availability of labors. Considering this scenario, devices, which helps the user to harvest areca nut palm easily will be useful for those having plantations as well as residents who is having less areca nut palm trees. This kind of devices will encourage more people to come forward to agricultural sector.

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 center of mass of the device outside the tree and it fused both spiral and straight climbs. An arm was provided in order to fulfill 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.

Rajesh Kannan, Megalingam, R Venumadhav, Ashis Pavan K, Anandkumar Mahadevan, Tom Charly Kattakayam, and Harikrishna Menon T, [2] analyzed various models of climbing and harvesting devices. Safety, reliability, ease of use, cleaning the tree tops, spraying pesticides were given prior importance. They designed a system that can be controlled by anyone. The designed prototype responds to human gestures with negligible gap in the response time. A prototype of the arm was designed and tested against human gestures and found successful. Their machine was designed to consume less power, so longer working hours doesn't affect the power consumption.

P. Mohankumar, D. Anantha Krishnan and K. Kathirvel, [3] discussed about the ergonomical parameters and ergo refinements of their design model. They designed two models and selected one through trial and error testing on basis of lower physiological cost, safety and discomfort. The inclination of the upper frame of climbing device is increased with respect to the horizontal, while moving towards the top. This resulted in unstableness and insecurity of the labor.

A design of tree climbing robot was presented by Rahul V, Sebin Babu, Sameer Moideen CP, Vineeth VP, Nikhil Ninan[4]. They used three linear electrical actuators - two for gripping and one for vertical up and down motion in their climbing device. They analyzed the model and found the design to be safe. Their climbing mechanism is very similar to a man climbing a tree. They tested their prototype under real life conditions and suitable changes were incorporated. In their paper, "Semi Automated Tree Climber", they discussed about the possibilities of modifying this device

Justin Gostanian, Erick Read [5]", discussed about the design, construction, and testing of a robot to climb trees to detect Asian Longhorn Beetle infestation. The primary goal was to design and build a robot that could successfully climb a tree. After researching existing climbing robot designs, a robot prototype was built using concepts from the existing designs. The prototype was then tested to determine the effectiveness of the design. The prototype proved to be partially successful, being capable of gripping a tree and staying on, but could not move. Though not entirely successful, the project identified many important aspects in a tree climbing robot's design.

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 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 first step was the collection and study of various data regarding the design and mechanism of the new product. The limitations of the current available systems were studied and analyzed, these results helped in creating a new design. A number of areca nut palms were observed and it was found that their diameter varied from 8-20cm. So, the robot was designed so it could cope with varying diameter.

The power supply for the robot can be provided from a DC battery or an AC current by using an adapter. The robot consists of two mechanisms: climbing mechanism and harvesting mechanism.

IV. DESIGN

Advanced methods for climbing and harvesting areca palm trees are very necessary in present scenario. The conventional methods include an experienced climber climbing the areca tree. This takes about 2-3 minutes alone just to climb the tree (This doesn't include cutting the areca nut and return trip). In more developed areas, methods of climbing and harvesting which involves rope-climbing gears and spiked shoes are used but are inefficient and impractical for large scale usage. Most climbers must climb around 20-30 trees per day in order to earn a meager income. In Kerala, a climber makes about rupees 750 per day. A climber climbs about 30-40 trees per day. In addition to pitiable wages, harvesters are looked down upon for doing the country's unwanted jobs. Hardly no-one aspires to become an areca nut harvester because of the unsafe conditions, low income, and social stigma, resulting in a virtual vacuum in the job market. Furthermore, this job is mostly male oriented. This is because of the traditional idea of it being a man's job as areca nut harvesting is extremely strenuous. The goal is to create a device that would allow operation by women and teenagers (as no hard labor would be necessary), thus creating an additional income opportunity for poorer families.

Competetive Technology

Although there are any mechanisms that can climb walls or trees, there are currently no robotic devices for climbing and harvesting areca nut trees in specific. One drawback of this mechanism is that they take much longer to climb a tree than human. One of the few specifically related devices we have found in our research is a climbing and harvesting device that aids in climbing a palm or coconut tree. The inventor asserts that his device ensures the user's safety and quickens the climbing process. However, the device still requires a person to physically climb the tree and therefore does not properly address the society's needs.

The above mechanism doesn't require human to climb the tree, but one has to drive it with the help of rope. It consists of a cutting blade and a climbing mechanism. Ropes are connected in such a way that by pulling the rope from bottom, the mechanism climbs upward. Holders are attached below the blade in order to hold the falling areca nut bunches. The grippers and rollers make the system move upwards and hold the mechanism in position. With the pulling action of the rope, the cutting blade gets enough power to perform the cutting.

PARTS USED

OPEN COIL HELICAL SPRING: A coil spring, also known as a helical spring, is a mechanical device, which is typically used to store energy due to resilience and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded.

One type of coil spring is a torsion spring: the material of the spring acts in torsion when the spring is compressed or extended. The quality of spring is judged from the energy it can absorb. The spring which is capable of absorbing the greatest amount of energy for the given stress is the best one. Metal coil springs are made by winding a wire around a shaped former- a cylinder is used to form cylindrical coil springs.

DESIGN OF SPRING

INITIAL DATA

Material used for spring = mild steel

Ultimate tensile strength of material S_{ut} =841Mpa

Standard size of spring wire or wire diameter of spring = 2mm

Outer diameter of spring = 16mm

Spring type =helical

DESIGN

Permissible shear strength of material

$= 0.5S_{ut}$

$= 0.5*841 = 420.5$MPa

Mean diameter of spring D

=outside diameter - diameter of spring

= 16-2=14mm

Spring index, C $= \frac{D}{d} = \frac{14}{2} = 7$

Stress concentration factor, k

$= \frac{4c-1}{4c-4} + \frac{0.615}{c}$

$= \frac{(4*7)-1}{(4*7)-4} + \frac{0.615}{7}$

$= 1.212857$

Shear stress in helical spring

$= 420.5 = \frac{8FDK}{\pi d^3}$

F = 77.76N

Maximum force that can be applied on the spring,

F = 77.76N

Load on the actual machine is approximately

= (weight of the machine * 9.81) + (cutting force)

$= (6.5 * 9.81) + 4$

$= 67.765$ N $<$ 77.76 N

Hence, design for spring is safe.

V. Fabrication

Climbing Mechanism

The climbing mechanism consists of a hexagon frame which can be opened and closed with help of a hinge. Tyres are fixed on to a clamp and are powered by DC motors. The main parts of climbing mechanism are:

Hexagonal Frame

It forms the base of the climbing mechanism. The shape for frame under considerations was hexagonal, round and rectangular. A hexagonal frame was selected as it required less material for providing the same amount of support compared to a rectangular frame and easiness of fabrication compared to a circular frame.

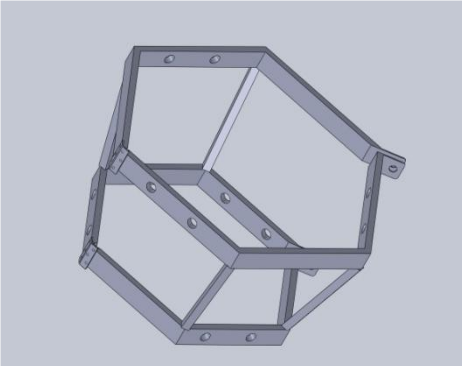

Fig.1 - Hexagonal frame

For fabrication, GI pipe was used as the material because of its greater strength, less weight, weldability and economical. It can withstand considerable stress without failure. The length of each link was 25cm. Each alternative link had holes in it for holding the tyres. The frame also had a locking arrangement for attaching to the tree.

U-Clamp and Motors

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 areca nut palm. The springs were designed for 4cm deflection, internal diameter 1cm and wire diameter 0.2cm.

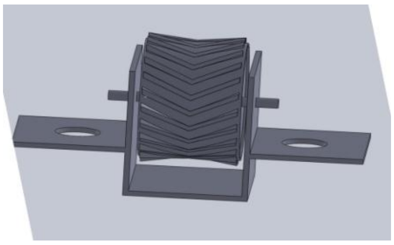

Fig. 2 - U-Clamp

The dimensions of the clamp were determined relating to size of the tyre and motor. The speed of the DC motors was 30rpm. This motor was chosen as it provided enough torque to lift the robot. Also, this motors provided a self locking so that the robot did not climb down due to gravity. The tyre diameter was decided based on the size of the frame.

Harvesting Mechanism

The harvesting mechanism consists of a rotating blade capable of movement in an arc. A rotating harvesting mechanism was used so that it could harvest the areca nut if present on both sides of the tree without having to align the robot manually. The main parts of harvesting mechanism are:

Base Frame

A semi-circular shaped base frame was attached to the top the hexagonal frame. The semi circular frame had tyres fixed on to it, capable of free rotation. The frame was fabricated using japan sheet and its dimensions were fixed realting to that of the frame. The tyres were fixed at equal intervals on top of the semi-circular frame.

C - Frame

A c-shaped frame which holds the motor for harvesting mechanism is kept on top of the semi-circular base frame. The c-frame has contact to the tyres only.

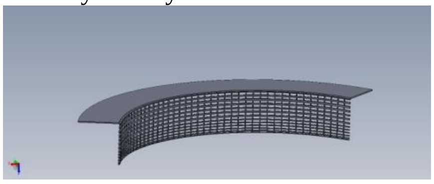

Fig. 3 - C-Frame

The c-frame is slid over the tyres with the help of a tyre driven by a DC motor attached to the hexagonal frame. The cutting blade is fixed to the motor on the c-frame.

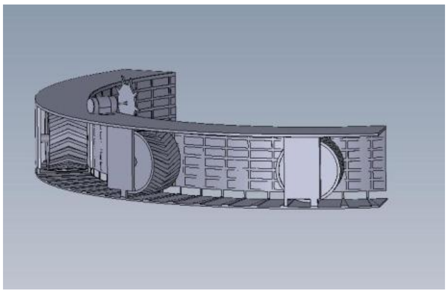

Fig. 4 - Harvesting mechanism assembly

The final assemby is as shown below :

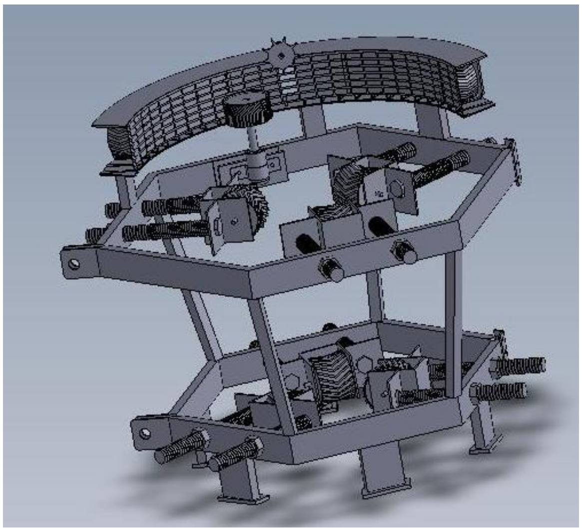

Fig. 5 - Final assembly

Working

The hexagonal frame is opened and attached around the tree using locking nut. The frame adjust to the diameter of the tree with the help of the springs. The robot moves up with the aid of tyre powered by dc motors. Once the robot reaches the top, the cutter starts working. The c-frame moves in an arc, cutting down the areca nut bunch from the side on point where it attaches to the tree. The robot is then brought down.

VI. Result and Discussion

The robot was successfully designed and fabricated. The robot was able to grip to the tree and climb up and down. The harvesting mechanism was successfully operated and it was able to cut down the areca nut bunch. It has the following advanges like Can climb large heights, Do not require skilled labour, No risk involved, Ease of handling, Low maintenance cost

VII. Conclusion

Constraints in the present models are overcome by the new design. Since the machine have to work for hours, it is made less power consuming. The maintenance requirement of the device is very less making it very convenient to use.

In future the device can be fully automated. Instead of controlling the switches, microcontrollers can be used and can be made wireless. Use of camera will make the device more easier to use. The materials can be replaced with Aluminum composites or nano fibers which are 10 times stronger and lighter than GI pipes. The project can be made more efficient by inclusion of pesticide sprayer.

The mechanism for harvesting areca nut will surely bring about a revolution in the traditionally labor intensive areca nut collection industry. Since the machine has to work for hours, it is made less power consuming. The maintenance requirement of the device is very less making it very convenient to use. In future the device can be fully automated. Instead of controlling the switches, microcontrollers can be used and can be made wireless. Use of camera will make the device easier to use. The materials can be replaced with Aluminum composites or nano fibers which are 10 times stronger and lighter than GI pipes. The project can be made more efficient by inclusion of pesticide sprayer.

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