DESIGN OF SEMI-AUTOMATED ARECA-NUT TREE CLIMBING PLUCKER

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Abstract: Areca nut plantation is one of the oldest types of plantation in India. Areca nut harvesting is done manually which involves skilled labours who climb the tree at least six times a year per tree to spray pesticides and harvest fruits. However in recent years skilled tree climbers have become scarce and farmers find it difficult to harvest the nut. Manually climbing the tree is very time consuming and the risks involved in this process is considerably very high.
The semi-automated tree climber and plucker is a machine which is designed to climb the areca nut tree and harvest it. The machine is wirelessly controlled and a machine vision is provided by a camera giving an insight of the tree crop even at high altitudes. Use of this machine eliminates the need for manual tree climbing and hence operator safety is increased and fatigue is reduced significantly.
The use of this machine will enhance the climbing, inspection and harvesting capabilities of areca nut plantations and give major contributions towards the increased productivity by reducing extensive labour costs and increasing safety considerably.

Keywords: Areca nut tree, climbing mechanism, harvesting mechanism

I. INTRODUCTION

Areca nut plantation is a major cash crop cultivation in India. Areca nut is extensively used in commercial processes as it has large medicinal applications. Apart from its vast uses, the harvesting methods used are still ancient and highly in-efficient. Even finding skilled labors has become tough as they should be capable of climbing high altitudes of the areca nut trees. Harsh weather conditions make the tree climbing process very difficult. Irregularities and defects in tree structures may also create difficulties in climbing.

Manual climbing is considered as one of the conventional tree climbing processes. It is a risky and tiring process where human fatigue is one of the major concerns towards the drawback of this process. Areca nut plantations range about 100-200 and more trees on an average basis hence in order to climb and harvest such a large number of trees, it is a real challenging task. Manually climbing the trees requires putting slots on the periphery of the tree which is not possible on trees with smaller cross sections and can also harm the tree. Sometimes insects, birds and flies also hinder the harvesting work of these plantations. The tree surface becomes slippery in rainy season due to the formation of algae over the tree surface. Also trees are susceptible to various diseases. Sometimes birds also prepare their nests on the trees which makes it difficult for the climber to access the tree.

Jananesh Bekal et. al. [1] has made a machine which works on the basic principle of friction with a X frame and two rollers at the bottom. The conical shaped rollers provide wedge action between the tree surfaces to maintain a strong contact. It also consists of a movable arm which can rotate at a 360 degree angle and is used for spraying pesticides. The system is connected to a Battery whose wires are passed all the way down the tree to the ground. The machine is controlled based on human judgment and also the system is only restricted up to the spraying of pesticides hence these drawbacks limit the use of this machine at a certain height up to a visible range.

Arjun Prasad et al. [2] has designed a harvester which uses friction to hold on to the palm tree with the help of springs. The machine is made adaptive such that it can adjust to the variable trunk dimensions of the tree. Adaptivity is made possible with the help of compression springs along the periphery of the machine. A video camera is used to give the input so as to where the fruit is located .This camera is coupled with a Zigbee microcontroller and Xbee RF module to control the machine wirelessly.

Jishnu K Das et.al. [3] have fabricated a machine working on the basic principle of rope pulley system. The shaft of the motor is welded to the drum which winds the steel rope around the tree. During the drum winding the spring gets contracted and the spring force acts opposite to the direction of the applied force. This opposite force generates an upward motion. The climbing down mechanism is by a rope which is tied on to lower and upper rings. When the rope is pulled from the ground the mechanism comes down in a step wise manner with the help of the rings.

[4] The obstacle negotiation capability of rod climbing robots and the improved mechanism design, [5] Design and fabrication of a column climbing robot (koala robot), [6] Development of an automatic self-balancing control system for a tree climbing robot, are used as reference to guide us in understanding and to help us come up with a new and improved design.

The objectives of the project include the design and fabrication of a semi-automated machine which is capable of climbing tall trees with varying circular cross sections. Also the design should be efficient in working and controlling compared to the existing machines such that the time required for installation and harvesting is made shorter and also to make the controlling of the machine user friendly so that person with very less technical knowledge is able to use it.

II. THE CONCEPT DESIGN

The semi-automated tree climbing machine is a remote operated machine. Once mounted on the periphery of the tree, it climbs the tree without any human intervention. The machine is a combination of three mechanisms namely the Body, the Climbing mechanism and the Harvesting mechanism. Use of this machine can be multidiscipline like climbing, spraying pesticides, inspection of fruit condition and harvesting the ripened fruit. The body of the machine acts as the base of the entire machine. It is made up of aluminium material such that it is light in weight as well as it is stiff enough to mainly absorb the forces acting on it. It prevents the twisting and bending of the machine under non uniform application of forces. It houses all the systems over it and prevents them from any damages while the harvesting process is in action. The frame consist of the climbing mechanism which provides grip to the machine over the tree surface. The frame also houses two batteries which power the entire machine. Apart from this it also holds the various circuit boards and wires which are required in the machine. The guideway for the arm is also connected over the frame such that it facilitates the 360 degrees rotation of the arm.

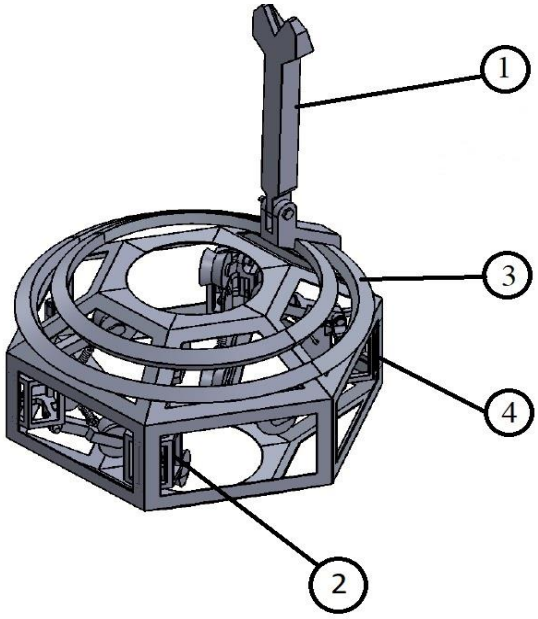

Fig 1: Assembly Model.

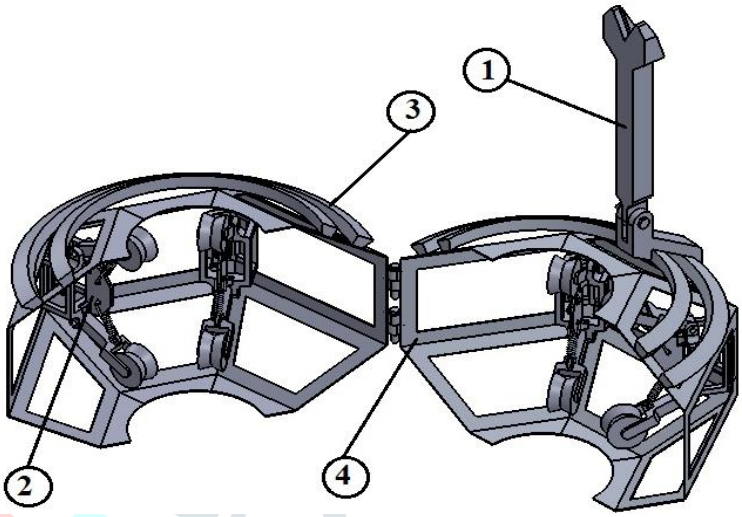

Fig 2: Detailed view of the Assembled machine.

Table 1: Part List

Parts No.	Part Description	Material
1	Harvesting arm	Aluminium
2	Climbing Mechanism	Aluminium
3	Guide way	Aluminium
4	Main Frame	Aluminium

III. CLIMBING MECHANISM

The climbing mechanism consists of links, springs, a Geared DC motor and rubber wheels. The motor is mounted over a link to provide the driving force. The rubber wheels and motor shaft are connected by a chain drive for power transmission. The rubber wheels are designed such that they provide the necessary coefficient of friction to maintain contact over the tree surface. The normal force required to hold the tires firmly on the tree surface, is provided by tension springs incorporated in the system. The machine consists of a total of four climbing mechanisms which are mounted at a 90 degree angle from each other. Each climbing mechanism has two links holding wheels on its end. Out of the two wheels, only one wheel is driving and the other is acted for properly guiding the machine over the tree trunk.

Table 2: Part List

Parts No.	Part Description	Material
05	Climbing Wheel	Rubber
06	Climbing Mechanism Body	Aluminum
07	Link	Aluminum
08	Tension Spring	Mild Steel

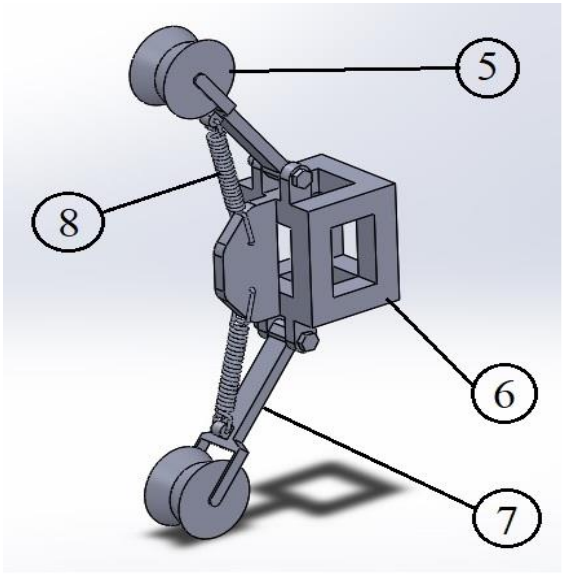

Fig 3: Climbing Mechanism

[7] Design data handbook for mechanical engineers, is used for obtaining equations and do the necessary calculations.

Preliminary calculations for total forces acting on the system
Total force acting due to weight of the machine (**F**):

$$F = \mu \times N \quad (3.1)$$

Considering total weight of the machine as 10 kg,
Hence, W=10 kg
Assuming μ= 0.25
Therefore,

$$F = m \times g \quad (3.2)$$
$$F = 10 \times 9.81$$
$$F = 98.1N$$

$$F = \mu \times N$$
$$98.1 = 0.25 \times N$$
$$N = 392.4\ N$$
$$N \approx 400\ N$$

Total resultant force acting (R)

$$R = \sqrt{F^2 + N^2} \quad (3.3)$$
$$R = \sqrt{98.1^2 + 400^2}$$
$$R = 415N$$

Force acting on each spring (R_s)

$$R_s = \frac{\text{total resultant force R}}{\text{no.of springs (S)}} \quad (3.4)$$
$$R_s = \frac{415}{8}$$
$$R_s = 52N$$

Torque on Wheels (T)

$$T = F \times \frac{D}{2} \quad (3.5)$$
$$T = 98.1 \times \frac{100}{2}$$
$$T = 4.905N\text{-}m$$

Rate of climbing of climber:

Total length of tree= 30mts (maximum)
= 30000mm

Circumference of the wheel $= 2 \times \pi \times \frac{D}{2}$ (3.6)
$= 2 \times \pi \times \frac{100}{2}$
$= 314mm$

Total no. of revolutions of the wheels

$$N=\frac{Total\ length\ of\ the\ tree}{circumference\ of\ the\ wheel} \quad (3.7)$$

$$=\frac{30000}{314}$$

=95rounds/min

N=100rounds/min

Motor Specification

Desired speed=100rpm
Design Torque=4.9N-m
Required voltage= 12V

$$\text{Power Required} =\frac{2\times\pi\times N\times T}{60} \quad (3.8)$$

$$=\frac{2\times\pi\times 100\times 4.9}{60}$$

=51.31W

Rated power=Design power×service factor
Rated power=51.31×1.2
Rated power=61.5W

IV. HARVESTING MECHANISM

Harvesting mechanism is designed to harvest the ripened fruit from the Areca nut tree. The mechanism consists of an arm which is positioned on a base which slides over a guide way. The guide way is further mounted over the body of the machine. The guide way is extended 360 degree such that it allows the arm to rotate over the guide way. This function of the guide way allows the arm to access the tree from all sides. The arm consists of a rotating motor having a cutting blade which when in contact with the stem of the fruit harvests the fruit. Along with the cutter it also has a camera enabling the operator to inspect the condition of the fruit and also cut it with precision. The cutter accesses the tree from the bottom and with an appropriate upward force, it cuts the fruit. Along with the cutting mechanism, the arm can also be fixed with a pesticide spraying apparatus for spraying pesticide.

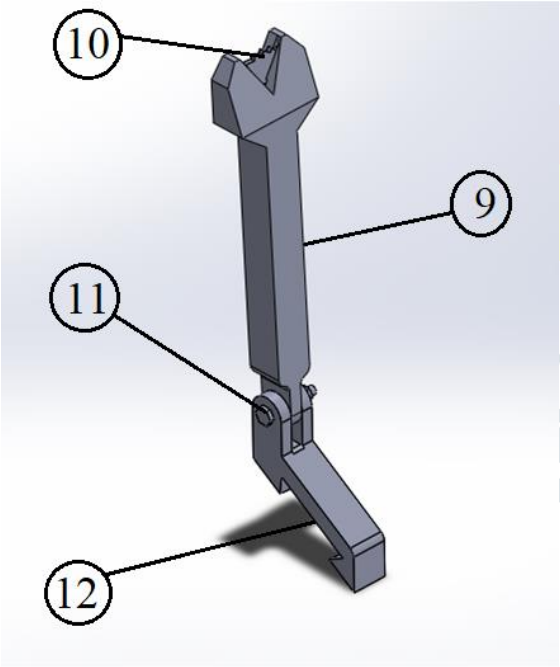

Fig 4: Harvesting mechanism

Table 3: Part List

Parts No.	Parts Description	Material
09	Harvesting Arm	Aluminum
10	Cutting Blade	Tungsten Carbide
11	Arm Pivot Screw	Mild Steel
12	Arm Mounting Base	Aluminum

Harvesting arm- cutting motor specification
Motor speed: 1000rpm
Motor torque: 0.5Nm
Arm mounting base- motor specifications
Motor speed: 50rpm

V. CONCLUSION

In Present day system, Areca nut harvesting is still carried out with involvement of manpower without appropriate safety measures which may lead to serious casualties which is also not economical and is time consuming. This project is intended to reduce human efforts for the harvesting of Areca nut. It can be controlled by a (RF) remote control which makes the control easy and is user friendly. It is economical since it is one time investment and as it is a wireless design the control and the working will be easy when compared to existing system. The use of semi-automated machine is versatile and will aid in increasing the production capacity of the farmers and reduce their dependency on skilled labors. Better visibility at high altitude will help farmer to take necessary action at right point of time. This will also reduce the spoilage of crop and increase the profit margins.

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