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Abstract —

The motivation of this paper is to make the robot interact with surrounding and cut the coconut autonomously. As technology is getting advanced things are getting simpler for us. By the mean of Autonomous it is possible to increase productivity and get things easier. The robot consists of hexagon chassis of two segments, in between two segments three motors and wheels are assembled. For automatic arrangement of robot with tree diameter, lead screw mechanism is used. The chassis is designed with the help of CAD software and analysis was done considering maximum load factor. For rotation robot about tree axis, motor mount is made such that it can rotate up to 90 degree. The motion of robot is manually controlled from ground using remote. For cutting of Coconuts robotic arm is used, on which cutting plate is mounted. Webcam mounted on robotic arm is used for giving feedback to controller. Motor driver, raspberry pi used for giving motion to robot.

***Index Terms*— Limit switch, Webcam, DC motor, robotic arm, and Threaded rod/lead screw mechanism**

INTRODUCTION:

Coconuts and coconut parts are used in wide applications in our daily needs. India produces near to 25% of the world's coconut meat and fiber, which produces oil, shampoo, rope, and doormats. To get coconuts laborers required much effort to get it from a tree. India produces maximum coconuts all over the world. But the farmers get a lot of problems in getting coconuts manually from the tree. All over the world farmers have difficulties to harvest coconuts. By now in maximum areas, farmers climb the tree to detached coconuts. As the growth of India is growing economically, numbers of workers are also moving to do jobs. Cutting of coconuts manually is a risky job, there are chances of getting an accident. By the survey it is found that the person who climbs tree get skin infection after

some year. As we know that there are lots of challenges faced while picking the coconut by climbing the tree. The user used to climb the coconut tree without any safety instruments and also it was time-consuming. So we came up with a solution that will make the user do the job with more safety and also in very less time with help of the robot that is designed below. To harvest coconuts, a better solution has to come, since it is difficult to detached coconuts. So to reduce farmer effort this paper is to provide a solution for them to detach coconut by the mean of Robot. The robot is controlled from the ground with the help of a remote. It will easily touch at top of the tree which of any irregular shape without any slippage. The robot is capable to rotate about three axes. The cost of a robot will be easily payable by rural area workers.

Here there is no risk of human life since the user will be directly controlling this via his Mobile App. The robot will also consist of Raspberry pi camera which will help in live streaming of coconut. This will help the user to identify the position of coconut through is Mobile App. Then the bot will be controlled accordingly to cut the coconut.

Akshay Prasad Dubey [1] a robot has 2 layers hexagonal chassis and working is done by using a lead screw mechanism. Calculation of power and Torque required to climb is done. Robot and cutting arm is controlled by wired controller. Eldho Jacob [2] autonomous tree climbing and pesticide spraying robot. The robot analyses and climb on the tree autonomously. Tree climbing Robot works on a principle of human pole climbers and relies on wheel mechanism to ensure smooth and fast climbing motion. The robot has made using 3D software and implements successfully. Electronic parts were accommodated on the electronic board perfectly. Calculation of power required to, upward force, and torque are done. This robot has been only a single-layer hexagonal structure hence it is not dynamically stable and the degree of freedom of robot is 2, which restricts its motion. Senthil kumar S [3] in this paper focuses on the designing and automated tree climbing robot, Tree robot which doesn't require human labor to the accompany the device but only to control it from the ground using a remote control. B.C. Widanagamage [4] has design Autonomous Tree Climbing Robot Utilizing the Four Bar Linkage System designed by the work was presented in this paper, it taken into focuses on designing Tree Robot. The mechanical structure is designed to move the structure upwards against the gravitational forces in the successive upper body and lower body movements similar to a tree climber. Yeoreum Yoon and Daniela Rus[5] this project is consist of making autonomous robot that will climb many large civil and industrial structures (e.g. bridges, towers, communication antennas, and construction scaffolds) and space structures (e.g. space station components and solar panel supports.). All the structural parts consist of PCB boards. A 6-DOF manipulator composed of two 3-DOF Shady3D modules and a passive truss element. The robot is able to move in all the directions, one side is get fixed with another bar and another side get removed to attached with another bar. "*Robot Modeling and Control*" written by "Mark W. Spong, Seth Hutchinson, M. Vidyasagar"[6]. Explained detailed about robot kinematics, motion planning, dynamic algorithm, trajectory optimization, and control of robots is explained.

Hence by studying and analyzing the issues and drawbacks faced by the above mentioned research papers, we came to a solution which we will be explaining below.

DESIGN OF ROBOT

The working of a robot overall depends on the design of the robot. Design of robot consists of three different branches:

1. Mechanical
2. Computer
3. Electronics

1. MECHANICAL:

The overall performance depends on the mechanical design of the robot. It consists of frame/chassis, selection of Chassis is done by the analysis of a given factor:

- Maximum load
- Material
- Weight
- Area constraints
- Stability

After analyzing different frames, the hexagon frame is selected as shown in Figure 1(a). Which consists of 2 stages, 2 stages are used for increased stability and to mount different components. Three opposite side is used for a motor mount. Two adjacent sides are used for the lead screw mechanism for variable length as required. And the front side is used for installation to a tree. With the help of the lead screw mechanism, the robot diameter adjusted with the help of remote such that robot will be fitted to a tree as shown in figure 1(b).

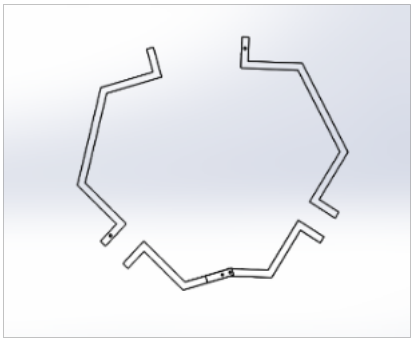


Figure 1(a). Hexagonal Frame.

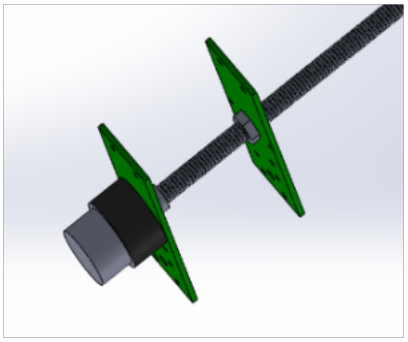


Figure 1(b). Lead Screw Mechanism

Figure 2(a) and Figure 2(b) shows the Isometric and the top view.

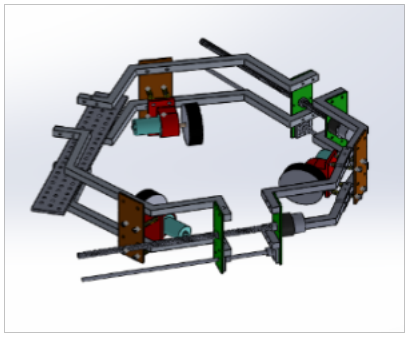


Figure 2(a). Isometric View

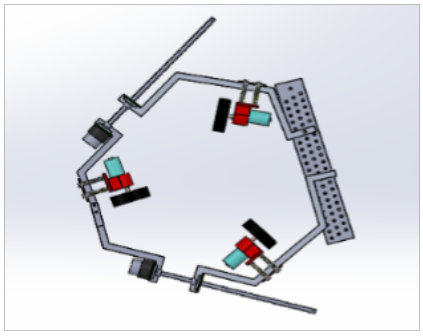


Figure 2(b). Top View

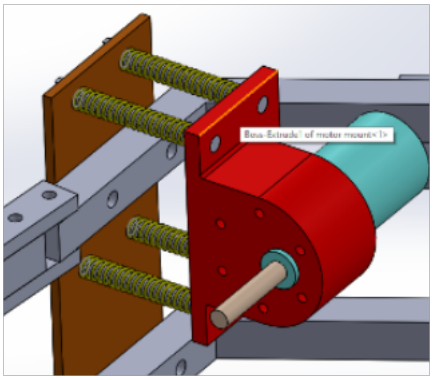


Figure 3(a). Motor mount

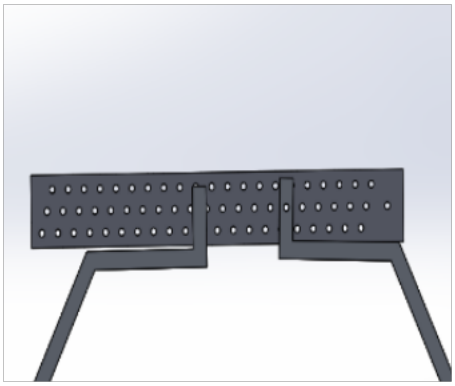


Figure 3(b). Variable sizing plate

To reduce weight and simple manufacturing motor mount is made by a 3D printer using PLA material. The motor mount is assembled on a 3mm Aluminum plate, and the Aluminum plate is attached with a frame with the help of springs. To maintain friction between wheels and trees, springs are used.

As shown in figure. 3(a) spring attached with the plate and motor mount used to maintain contact with a tree. Initially, the robot is assembled with a tree manually by the worker. Then as per diameter worker will be fixed the plate with the help of a screw. As there are many holes, the hole are use as per requirement, shown in figure. 3(b).

Dimensions:

Design of robot is done such that, as per requirement of diameter of tree, bot will adjust accordingly. As shown figure 4(a) and figure 4(b) minimum diameter that robot can cover is 150 mm and maximum diameter of 400 mm. To increase diameter of bot, side motors will rotate in Clockwise direction and to decrease diameter of bot motor will rotate in anticlockwise direction.

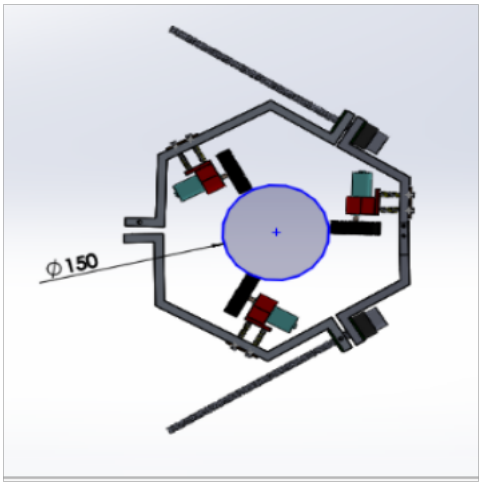


Figure 4(a). Minimum Diameter.

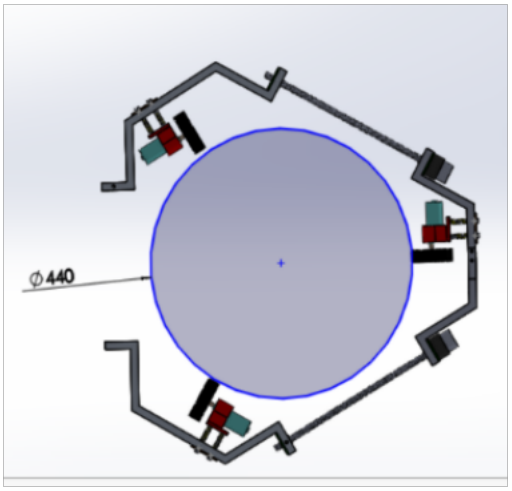


Figure 4(b). Maximum Diameter

Properties of material used (Aluminum) for making frame/chassis given below:

Table No: 1 (Properties of materials)

Property	Value	Units
Elastic Modulus	69000	N/mm^2
Poisson's Ratio	0.33	N/A
Shear Modulus	27000	N/mm^2
Mass Density	2700	Kg/mm^3
Tensile Strength	68.9356	N/mm^2
Compressive Strength	--	N/mm^2
Yield Strength	27.5742	N/mm^2
Thermal Expansion Coefficient	2.4 x 10^-5	/K
Thermal Conductivity	200	W/(m.k)

After defining material to all different parts and considering the load of electronic parts, the center of Mass of final assembly comes at the center of the robot i.e. (X≈0, Y≈0, Z≈0). So that robot remains balanced at the time of its working. The Analysis was done on Solid Works software which is given below:

Mass Properties:

Mass = 2279.35 grams

Volume. = 1432001.88 mm^3

Surface Area = 554386.90 mm^2

Center of Mass (considering center as origin):

X≈ 0.0

Y≈ 0.0

Z≈ 0.0

Principal axes of inertia and principle moments of inertia: (gram*mm^4)

Principal axes of inertia and principle moments are taken at the center of mass:

I_x = (-0.26, -0.06, 0.96) P_x = 49930131.81

I_y = (0.97, 0.00, 0.26) P_y = 57558033.50

I_z = (0.01, 1.00, 0.05) P_z = 95039916.56

Components used:

1. 3 wheels
2. 3 motor mount
3. 12 springs
4. 2 threaded rod
5. 3+2 Johnson geared motor (2kgcm, 200RPM)
6. Aluminum 12.7*12.7 mm^2 bar

Stress Analysis:

Various Loads acting on Chassis are:

1. Load acting due to Cutting arm

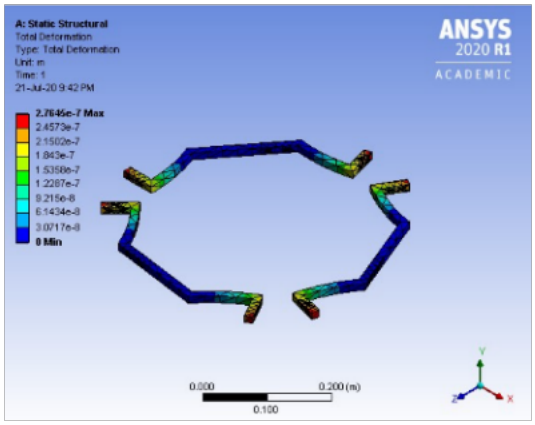
2. Load when robot climb tree

3. Load acted by Electronic components

Efficiency of robot Depends on capability to sustain maximum external Load. For that weight reduction plays an important role.

We have done analysis for different materials (considering its self-load). After analysis maximum efficiency and productivity comes out of Aluminum bars.

Below shows Total Deformation and Equivalent Stress (Von Mises stress) analysis of robot under single and double stages:



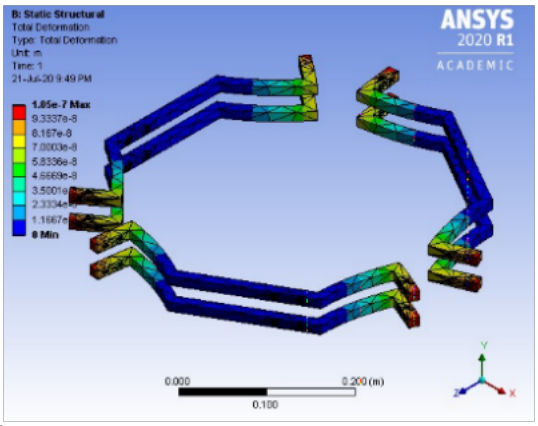


Figure 5(a).Total Deformation of one layer Figure 5(b). Total Deformation of one layer

Figure 5. Total Deformation

The selection of Chassis is done through the analysis of different orientated chassis. Design of chassis is done on SolidWorks software, and stress analysis is done on Ansys Software. Figure 5(a) and figure 5(b) shows Total deformation of single stage chassis and double stage respectively.

Maximum deformation

One stage chassis: $2.7645*10^{-7}$ m ……(1)

Two stage chassis: $1.05*10^{-7}$ m ……(2)

From equation 1 and 2, it is concluded that 2 stage chassis is more acceptable.

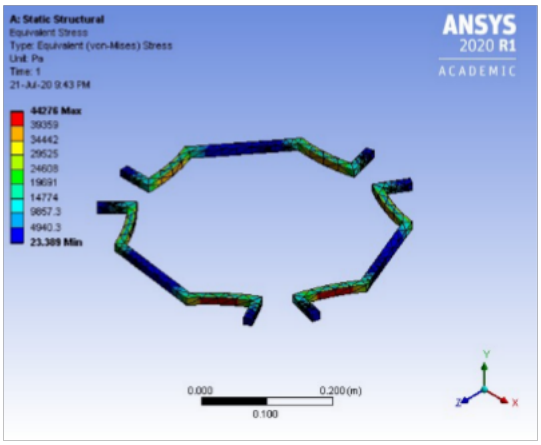


Figure 6(a).Equivalent stress of one layer

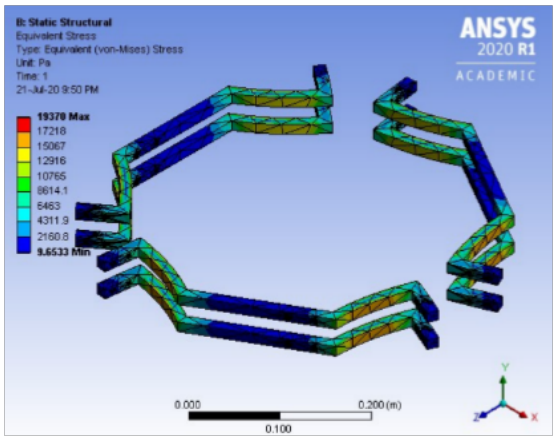


Figure 6(b). Equivalent stress of one layer

Figure 6. Equivalent stress

From figure 6(a) and 6(b), Equivalent stress:

One stage chassis: 44.276 MPa from fig. 6(a)

Two stage chassis: 19.370 MPa from fig. 6(b)

From stage one to stage two equivalent stress reduced to half, which defines that selection of two stage chassis is better than single layer chassis.

Design of Arm:

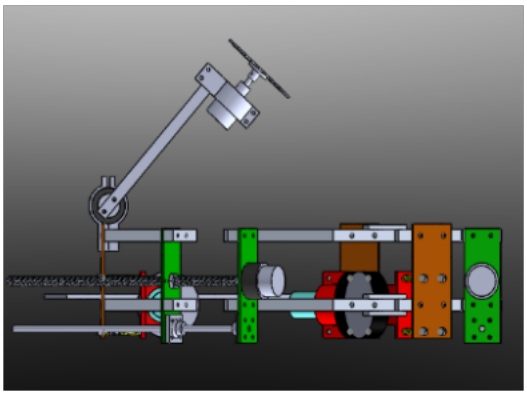


Figure. 7(a) Side view

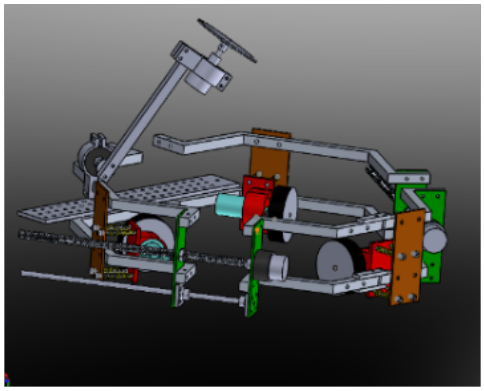


Figure. 7(b) Isometric view

Figure. 7 Design of Arm

Design of final assembly of robot shown in figure 7(a), the Degree Of Freedom (DOF) of mechanism is 3. To reduce the overall weight we have modified the solid aluminum to hollow aluminum bar of dimensions

12.7*12.7 mm^2 with thickness of 2mm square bar. The motion of arm is controlled remotely by Wi-Fi of Raspberry pi. If in case coconut is situated on the opposite of the arm, then the bot has a facility to rotate itself along periphery of the tree. By this the user can easily navigate the robot. The cutting

mechanism of coconut is done by using DC Motor, coupled with motor which is attached with frame. The motor has rating of 12V which rotates at max 1200rpm.

2. Electronics

1. Raspberry pi:

Raspberry pi is used for processing the inputs received from the components, in form of voltage or current, and converting it into readable signals or voltage. Also it is used for image processing in order to convert the image into greyscale, which later on is further processed to tensor flow for image recognition. The processed image is being displayed to the user, who is controlling the robot, via android device. Since it has inbuilt Wi-Fi, also the number of pins required for the functioning of the bot is present in this module we preferred to use this module.

Wi-Fi (inbuilt in Raspberry pi): (Purpose)

- In order to control the bot while climbing the tree.
- Also to control the actuators needed to pluck the coconut and cut the branches that are required.
- Also to give the live stream of the camera attached to the Raspberry pi.

2. L298N:

Motor driver which can sustain a voltage up-to 30 volts can be used for delivering stable voltage and current to the motor. The working of 7 different motors are done by Four L298N H bridge motor controllers. Three motors are attached with frame for up and down motion. Two stepper motors are used for arm controlling and two motors for adjustment of the diameter of the bot according to the tapering diameter of the tree. If there is any slippage then, the side motor will rotate in clockwise direction to avoid any discontinuity in motion.

3. Lithium Polymer (Li-Po) battery

To provide power supply to motor controller and Raspberry pi, we have used two Li-Po battery, each of 12V i.e. total power of 24 V is provided. We had an option for lithium ion battery but instead of that we have used Li-Po battery.

Given below advantages of Li-Po battery:

- Lightweight
- Retains charging capacity better than Li-ion battery
- Conversion rate: 80-90%
- Charging duration is comparatively shorter than Li-ion battery
- Li-Po battery is safer, less chance of explosion compare to Li-ion battery.

Control algorithm flow chart

Here we use Arduino and Raspberry Pi for controlling a robot. Arduino is used for controlling the L298 motor driver, which is used to control BLDC Motor (Lead-screw mechanism), High torque motor for

climbing, and Arm motor. With the help of Raspberry, Pi video is shown on a display of controller using Pi camera, communication between Raspberry Pi and controller is done by using Wifi Module. Which makes a robot friendly useable. There is no difficulty while cutting coconuts. Below Figure 8(a) shows detail about the flow of working of robot.

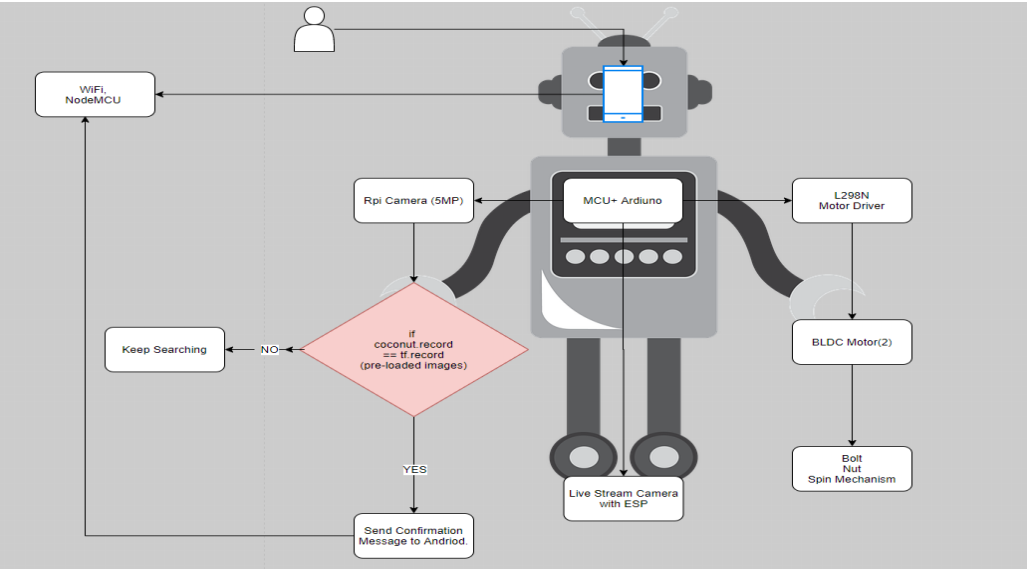


Figure No. 8(a) Flowchart of working

4. Conclusion

From the research finding it is observed that hexagonal chassis is the most efficient in terms of stress distribution and also provides an advantage for maintaining a good contact between the tree and the wheels. As the bot moves upwards it automatically configures the diameter and doesn't lose the contact, which is achieved by controlling the lead screw mechanism. From the finite element analysis it is observed that the double layered chassis structure of robot is having lowest deformation as compared to the single layered chassis robot. The results have been compared and is well suited with our project objectives

5. Acknowledgment

First we would like to thank our parents for their constant guidance and endurance throughout our research. We thank our guide Assistant Professor. Rahul K Patil, for guiding us throughout the project and The Robocon Team for technical assistance. We also wish to express our appreciation to our lecturers and the Dean, School of the Mechanical and Civil Engineering, MIT Academy of Engineering, Alandi for their continuous support and guidance.

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