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DESIGN AND FABRICATION OF COCOBOT

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Abstract: *Coconut palms are growing in more than 90 countries, with a total production over 60 million tons..In the conventional method coconuts are harvested a person need to climbing the tree and cutting the nuts by hand. It is quite dangerous and due to the fact nowadays only few peoples are coming to the field. COCOBOT is a coconut harvesting device, it mainly comprises of two mechanisms namely a climbing mechanism and a harvesting mechanism. The climbing mechanism consists of rectangular shaped chassis which can be opened and inserted into the trunk. Two motor powered wheels are set on opposite sides of chassis which will help in climbing. The robot has an auto-fastening mechanism using springs and the linear steppers attached to the wheel sets on the two sides so that the robot can provide better grip wrapped around a tree trunk and accommodate any size variations along the trunk. The harvesting mechanism consists of robotic arm which mounted over the Chassis. The arm has three degree of freedom with a four jawed gripper as an end effector. The mature coconuts are on the tree located by a wireless camera which is placed at the wrist of the arm. The nuts are harvested using the gripper based on the output received from the camera. The entire movement of the COCOBOT and the harvesting mechanism is controlled using remote control. The arm movements and climbing operations were controlled from the ground by an operator. .In additional rotating circular blade can also help in cutting leafs effectively.*

Keywords: Coconut Harvesting, Harvesting Mechanism, Climbing Mechanism, Robotic arm.

1. INTRODUCTION

In olden days most of the activities were done manually. Gradually so many big and small equipment's were developed to ease human activities, thus to lessen the human efforts to do the things. Nowadays most of the activities which included human efforts were either replaced or automated by the use of machines or other kind of equipment's

India is the third largest producer of coconut in the world. Coconut is grown in an area of about 18.7 million hectares with a productivity of 5718 nuts per hectare in India (National Horticulture Board, 2011). Usually all over the country, farmers practice conventional harvesting method in which coconuts are picked by specially trained, skillful and experienced climbers. Due to the height and lack of branches, it is very difficult to climb on coconut trees. A professional climber with proper training only could climb coconut tree. Due to the risk involved, nowadays a very few are coming forward to climb on coconut trees. Due to the lack of professional climbers, the existing professionals may charge more from the owners. Many young men now avoid coconut-picking in favors of white collar jobs, meaning there is no longer a guaranteed labour force. Coconut Tree climbers are a rarity these days. The scarcity of labour disrupts harvesting cycles causing loss of income to the growers. As against the general norm of harvesting cycles of 45-60 days, farmers are currently able to harvest only once in three to four months. Considering this scenario, device which helps the user to climb coconut tree easily will be useful for those having coconut cultivation as well as residents who is having less coconut trees. This kind of devices will encourage more people to come forward to agricultural sector.

2. PROBLEM STATEMENT

Coconut and coconut products find variety of uses. Coconut and coconut milk is used for cooking. Coconut water is a healthy and refreshing drink. Coconut shells and husk can be used to make different household and flooring materials. Coir and stuffed mattresses are made from coconut husk. Coconut oil is another major product. It has a major role in Ayurveda treatment The problem that we are facing is the harvesting the coconuts .The structure and height of the tree is the problem. It requires skilled labour to climb and also it is very risky job. If the person climbing the tree loses the hold on the tree or if he fails to grip when he reaches the top side, there is a chance that he may fall from the top. There comes the importance of a proper gripping mechanism that helps people to climb.

It is time that we look for alternate solution in which we can harvest coconuts without man power. Robotics and Automation could be a possible solution. We have to solve several issues like how the robots hold the tree, how much user friendly, how much durable etc. Different mechanisms has to be applied. Designing a vertical climbing robot is a difficult one than normal rover bots. And also the structure of the tree is also an important parameter to be considered. Tree cross sectional area may vary in each tree and it may vary in same tree from top to bottom. Height of the tree is another parameter which plays an important role in the case if we are controlling it from the ground. Proper communication channels has to be chosen for controlling the rob ot. Likewise there are so many parameters that has to be considered while designing such a system. This paper deals with different possibilities and mechanisms for harvesting coconuts.

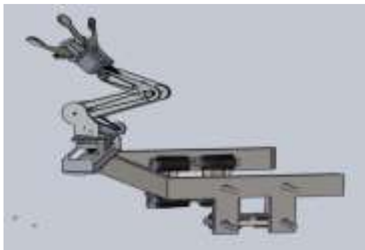

Fig.1CAD final assembly of coconut harvesting robot**.**

3. Climbing Mechanism

It is a rectangular shaped structure with two sets of spring loaded wheels with linear actuators opposite sides of base frame. The climbing system can adjust according to the size of the tree. . It can accommodate the size variations and small obstructions on the wheel path. Each set wheel is driven by a stepper motor with help of V-belt and pulley. These drivers are fixed on the frame of the device .The robotic with linear guide way assemble is pin joint to the base frame which help the robotic arm to get maximum coverage across the tree, For portability and ease of use, the robot is equipped with a clip lock on one side of the robot frame that serves as a manual lock and can be opened or closed to be inserted onto the tree trunk .Wheel locking is provided so that it help to held the device at certain position during its plucking operation

3.1. Robotic Arm

It has three links with three servo motors and the three jawed plucker with two servo motors. The three linked mechanism provide three degree of freedom to give the arm so it can easily locate the position of coconut. The three jawed plucker consist of two motion one is to grab the coconut tightly by worm wheel and geared jaws mechanism and the other for rotating jaws along center of axis. The arm is made of aluminium with a length of 400 cm. The arm can move up and down using stepper motor by a pulley. The stepper motor rotation is converted into linear motion using a timing-belt. The arm linear movement is designed to be able to reach the coconuts. At the top arm, a specifically designed saw and wireless camera are attached. The saw is designed using DC motors for high speed rotation in order to quickly cut the coconut stem. The blade is a sharp grinding for cutting.

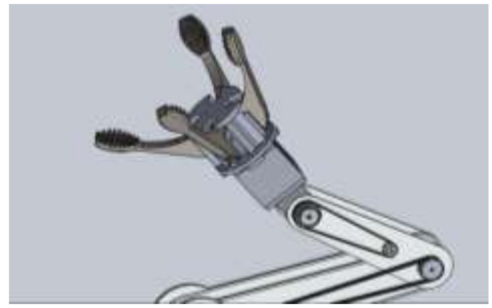

Fig.2. Robotic Arm

3.2. Camera Module

Wireless camera is mounted over the robot arm, which is connected android device. This helps the user to visualizing the relative position of Coconuts .So the person standing on the ground could easily identify the matured coconuts. Camera is tilted to the desired position and thereby the tele-operating of cutting arm accordingly

3.3. Control Unit

ATmega328 is the microcontroller used for the robot. It has 32 bit RISC architecture which consists of 28 pins. As it is simple and low powered it is well suited for this application. External RC remote is also being attached to the robot, which enables the human to control the robot manually. RC is chosen over many other alternatives including InfraRed because of its ability to work beyond the LOS. This property is exploited over here when it reaches the treetop. The control system divided into two, one control the climbing motion and other for the operation of the robotic arm

4. MECHANISM AND WORKING

4.1. Climbing System

The robot showed relatively well to move up and down on a tree, auto-fastening using the spring and linear actuator has shown quite well in reducing and adapting to varying coconut tree trunk diameter, so that the robot could climb coconut trees quickly. The average height of a coconut tree is approximately 20 meters, so that the robot maximum speed to climb-up above the palm tree is within 22 seconds, Accelerometer sensor influences the rotation of the wheel motor in order to maintain the robot movement to be balanced and not skewed.

Table 1. Robot Wheel Rotation Speed

Wheel diameter 80mm			
PWM	RPM	RPS	cm/s
128	102	1.7	42.7
160	130	2.17	54.43
192	159	2.65	66.57
224	188	3.13	78.71
255	215	3.58	90.01

The experimental result is conducted so as to roughly bala nce the robot due to high noise which could be attributed b y limited space of sensors placement. Testing data on accel erometer can be seen in table III. Data sensor processing w as performed using a common low pass filter in order to re move high frequency noise due to undesired vibration.

4. CALCULATION

4.1Design of cutting blade

Cutting force Force acting on the tooth of a circular saw takes chips at the width b and thickness h. The cutting force value is then given by the multiplication of cutting resistance for disintegrated material K(K=2-3 for soft wood) and the surface of chip crosscutting.

$F_c = K \cdot b \cdot h$ (N)

F_c =3x.0054x.008 (Assuming chip width(b)=0.001m and thickness (h)=0.003m)

F_c=1.296x10^{-4}N

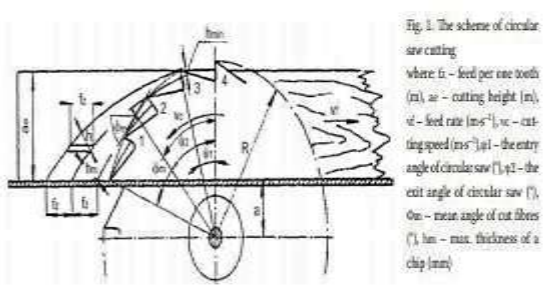

Fig 3. Scheme of Circular Saw Cutting

The cutting power is defined as the multiplication of cutting force Fc and cutting speed vc (v_c=100ms^{-1} for soft wood)

$P_C = F_c \times v_c$

P_C=1.296x10^{-4}X100=1.296x10^{-2} W

Considering following specification we choose high speed steel with Saw diameter D =6mm

And Saw width b =5.4 mm and Cutting clearance angle α= 20°Cutting-edge side rake angle =5^0 No. of teeth=56

Cutting Torque $M_k = P_c$x60/2π Nm

M_k= (1.296x10^{-2} x60)/2π =0.12375Nm.

4.2 DESIGN OF CUTTING MOTOR

Generic RS-775 DC Electric Motor for Drill 12V, 24V Brush Motors is suitable while considering torque and speed.

4.3DESIGN OF ROBOTIC ARM

Holding force required while cutting = 7.5N (experimental result)

So Torque required for link 1 of robotic arm

T_1 = (weight1+holding torque) x distance x cosine angle (Weight of motor1=0.250kg)

= (7.5+2.5) X 15 X cos 60= 75N-cm=0.75Nm

For 7.64kgcm torque we choose NEMA17 Stepper motor with 4.5kgcm torque with timing belt and pulley transmission ratio 2:1(GT2 Pulley with 40 teeth and 20 teeth with belt of width 6mm) so we get maximum torque 9kgcm.

2) Torque required for link 2 of robotic arm

T_2= weight2 x distance x cosine angle (Weight2=weight of motor1 (2.5N) +holding torque (7.5N) +weight of first link (2.5N) +weight of motor2 (3N))

= (15.5 x35 x cos 60) = 271.25Nm-cm =2.7125Nm

For 27.65kgcm torque we choose NEMA23 Stepper motor with 10kgcm torque with timing belt and pulley transmission ratio3:1(GT2pulley 60 and 20 teeth) so we get maximum torque 30kgcm.

2) Torque required for link 3 of robotic arm

T3= weight3 x distance x cosine angle(Weight3=weight of motor1(2.5N)+holding torque(7.5N)+weight of first link(2.5N)+weight of motor 2(3N)+weight of link 2(4)+weight of motor3(6N))

= (25 x55 x cos 60) = 687.5N-cm =6.875Nm

For 70kgcm torque we choose NEMA23 Stepper motor with 18.5kgcm torque with timing belt and pulley transmission ratio 4 :1(GT2pulley 80 and 20 teeth) so we get maximum torque 74kgcm

4.4DESIGN FOR CLIMBING UNIT

Weight of the machine, W = 13 kg

W = 15x9.81

W = 147.15N

Assuming coefficient of friction between tree and rubber grip, μ = 0.3

Actual Force to be lifted, F=W/μ

F=147.15/0.3

F = 490 N

4.5SELECTION OF THE WHEEL

Average Change in circumference of the tree is taken as 30cm to 80cm. It was observed that the maximum circumference of a coconut tree is 80 cm and minimum circumference at the top is 30 cm. 8cm wheel is used in this machine for the torque restriction of the motor.

4) Torque required for climbing T= F x r =490 x0.04 =19.6Nm r= radius of wheel=4cm

For 199.9 kg cm torque we choose two nema 23 stepper motor with torque 25kgcm with transmission ratio 4.5:1(GT2Pulley 90 and 20 teeth).We maximum torque=2x(25x4.5)=225kgcm.

Torque on individual wheel = 225/8 = 28.125Nm

Force acting on each wheel F_W=28.15/0.04(F_W=T/r)=703.125N

So we select ABS fiber composite wheel with maximum 80kg bearing capacity

4.6DESIGN OF SPRING

After Various trial and error calculations, where in we saw that the entire spring calculations depended upon either the number of coils or amount of minimum deflection, where in we had a minimum number of number of coils, which when exceeded would not allow for further compression, we had to do trial and error on the minimum value of deflection at minimum diameter and with maximum load.

1. Deflection= Y min =1.6cm

Y max = 5.5cm.

2. Free Length= 9.5cm

3. Number of turns=17

4. Number of turns=4.25cm

5. Spring Index C=6

6. Spring Constant= K =

K= 1.2525

7. Shear Stress= τ = 8FDK/πd3

(τ) max= 210 N/mm2

8. Nominal Shear stress= τ = 8FDK/πd3

(τ) max= 210 N/mm2

9. Wire Diameter= d = 2.36mm

Approx. 2.5mm

10. Mean Diameter= 14.8cm Approx. 15cm

5. Working Principle

The base frame is equipped with a clip lock on one s ide of its frame that serves as a manual lock and can be ope ned or closed to be inserted onto the tree trunk.The rigid s upport will restrict the wheel motion in vertical direction while spring will give adjustments to the wheel in directio n perpendicular to the trunk. Wheel shaft is then joined wit h a high stepper motor shaft by means of a coupler which will give rotations to the wheel so as to climb up the tree. O nce the region to harvest is reached. The wheel motions ar e arrested by wheel locking provided.

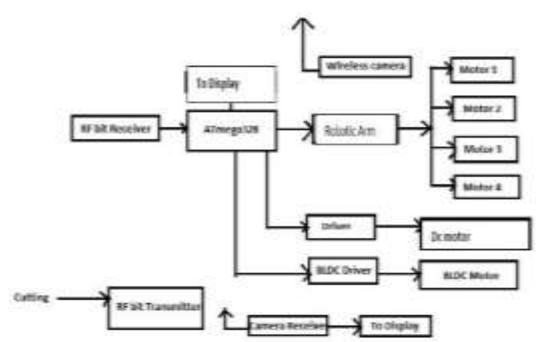

Fig.4: Block diagram of receiving section

The camera placed on the robotic arm will transmit virtual information about the relative position of coconut with res pect to the arm, which is displayed on android device on th e users end. So the user can locate the coconuts with help o f tele-operated robotic arm, further the three jawed plucke d grabs the coconut and start to rotate on its own axis whic h will result in the breakage of coconut spike. The robotic a rm gets full coverage around the tree with the help of pin j ointed linear guide way at the base frame. The overall oper ations controlled by a person standing on the ground.

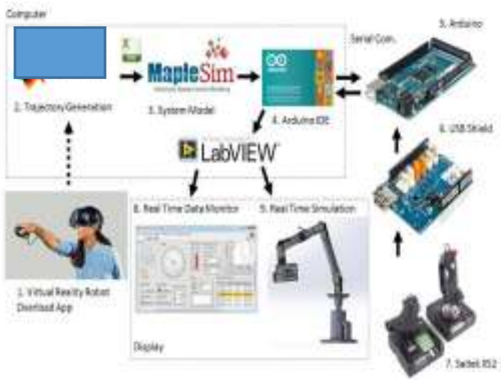

Fig.5. Tele–Operation System Configuration

6. PRODUCT DESIGN

The first step was the collection and study of vario us data regarding the design and mechanism of the new pr oduct. Next step was to design the model using AUTOCAD I nventor. Then static load analysis of the model was done u sing Nastacad 19. In the static load analysis, total deformat ion and maximum stress induced were determined. Then we moved on to the fabrication part. Selection of material was the first step for fabrication.

For fabrication, Aluminium was used as the materi al for robotic arm because of its high strength per weight r atio and affordable cost, and MS was used as material for b ase frame because it's less expensive compared to others . The next step was the selection of suitable powering devic e for the gripping and vertical motion of the mechanism. F or this we chose two sets of spring loaded wheels with line ar actuators on opposite sides of the rectangular base and t wo sets of C-clamps. For the smooth climbing operation we used four stepper motors for powering the wheels. The tw o C-clamps for gripping, having a stroke length of 15 cm an d providing 40N. For vertical motion High Torque stepper motors are used capable of providing a torque of 10kgcm was used. A 12 V DC battery was used to provide power for the actuators.

7. CONCLUSION

Constraints in the present models are overcome b y the new design.. This project can bring together several c omponents and ideas of robotic technology to use it for the society to handle the risky task of the coconut farmers to p luck the coconuts instead of personally climbing the tree b y the farmers. This project can be utilized for the similar ki nds of task

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