Coconut Harvesting Robot.

Bhargav Joshi[1], Bhushan Hurali[2], Prafful Jain[3], Sanjay Suthar[4], Uthej Dalavai[5]

Abstract—Primary goal of the paper is to aid people in the design of a coconut tree climbing robot for the purpose of coconut harvesting. It is very difficult to climb a coconut tree manually due to the structure and the contour of the tree. Generally trees have branches onto which a person can climb and extract fruits, but not in the case of a coconut tree, where there are no branches for support. Due to the risks involved, nowadays farmers hesitate to climb the coconut tree to extract coconuts. Even the agricultural workers employed for coconut harvesting hesitate to do the job because they suffer from musculoskeletal disorders in the long term. The number of workers who can do this job is decreasing by the day. Hence there is a need for a machine/Robot which can do this job in place of humans. In this paper, we aim to discuss the design a mechanism which is simple and easy to operate.

Index Terms—Automation, Agriculture, Agricultural Robotics, Agricultural Engineering,Engineering, Farm Robotics,Robotics.

1 Introduction

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, skilful and experienced climbers. Due to the height and lack of branches, it is very difficult to climb on coconut trees. Many researchers all around the world have worked on climbing robots most of these climbing robots are capable of climbing regular structures like poles, walls, domes 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 robots cannot be used for tree climbing applications. Many trees like coconut tree, areca nut 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 olden days most of the activities were done manually. Gradually many equipment were developed to ease human activities, thus to lessen the human efforts to do the things. Presently most of the activities which included human efforts are either replaced or automated by the use of machines or other kind of equipment. This paper intends to discuss the possibility of reducing the human effort in extraction of Coconuts with the help of a robot.

2 Procedure for Paper Submission

2.1 Review Stage (Literature Survey)

Mani and Jothilingam[1] discussed the development and fabrication of a semi-autonomous tree climber and harvester (COCOBOT). COCOBOT comprises of two mechanisms namely a climbing mechanism and a harvesting mechanism. The climbing mechanism consists of an octagon shaped chassis. Four active wheels are set at specific intervals around the tree of which one pair is for the upper side and the other for the lower side of the chassis. The main features of the climbing mechanism include the location of centre of mass of the COCOBOT outside the tree and the innovative climbing strategy fusing the straight and spiral climbs. The harvesting mechanism consists of an arm with three degree of freedom with a circular saw as an end effector. The bunch of nuts is located by a vision sensor (camera) which is placed at the wrist of the arm. The nuts are harvested using the saw based on the output received from the camera. The entire movement of the COCOBOT and the harvesting mechanism is controlled using remote controller.

Rajesh Kannan M., Thejus P. et al[2] in their paper discussed the design and application of a robotic arm for the purposes of harvesting cutting of the coconuts from the coconut tree.

Megalingam, Venumadhav et.al [3] in their paper, discussed various models for tree climbing and plucking. He took into account the safety, reliability, the ease of use which is capable of climbing trees, cutting down coconuts, cleaning the tree tops and spraying pesticides. He designed a system that can be controlled by anyon. The designed prototype responds to human gestures with negligible gap in the response time and hence can be implemented in real time.

DileepEdacheri, Sudhindra Kumar, Prakash Unakal in their paper discussed the task of coconut extraction without any automated machinery but instead with a simple mechanism which gives the climber enough support. The mechanism is based on how the workers actually climb the tree, i.e. with the help of a rope.

Justin Gostanian, Erick Read in their project report discussed the numerous tree climbing designs that exist already and how those can be used to climb on different kinds of trees.

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2.2 Final Stage (Design)

The design for the gripping mechanism includes links for movement, gripper to grip the bark of the tree, and a pneumatic cylinder to actuate the mechanism. This is shown in Fig.1 to Fig.6

Fig.1 (Baseplate)

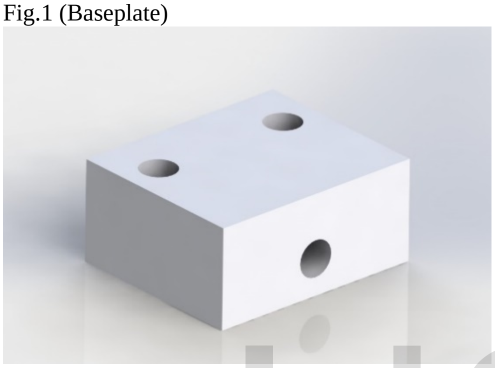

Fig.2 (Block)

Fig.3 (Gripper)

Fig.4 (Link1)

Fig.5 (Link2)

Fig.6 (Gripping mechanism)

The movement of the pneumatic cylinder in turn moves the block which moves the link 1 which again moves the link 2, this link is attached to the gripper. The linear motion of the actuator (cylinder) enables the mechanism to grip or release the bark of the tree.

3 Citations

[1] Mani A, Jothilingam A, "Design and Fabrication of Coconut Harvesting Robot: COCOBOT", International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Special Issue 3, March 2014.

[2] M. Rajesh Kannan, P. Thejus, P. Allan, V. Trayesh, M. Gokul, "Robotic Arm Design for Coconut-Tree Climbing Robot", Applied Mechanics and Materials, Vol. 786, pp. 328-333, 2015

[3] R. K. Megalingam, Venumadhav, R., Pavan, A., Mahadevan, A., and Charly, T., "Kinect Based Wireless Robotic Coconut Tree Climber", in 3rd International Conference on Advancements in Electronics and Power Engineering, 2013.

4 Equations

1. Load lifting capacity of the pneumatic cylinder:

Pressure, $P = 6$ bar $= 6 * 10^5$ N/m^2
Piston diameter, $D_P = 0.02$ m
Rod diameter, $D_r = 0.01$ m
Cross sectional area of Piston, $A_P = \pi r^2 = 3.1415 * 10^{-4}$ m^2
And Cross sectional area of Rod, $A_r = \pi r^2 = 0.7854 * 10^{-4}$ m^2
We know Pressure = Force/Area
$\therefore F = p * A$
$F = (6 * 10^5) * (A_P - A_r)$
$F = (6 * 10^5) * (2.3565 * 10^{-4})$
$F = 141.39$ N
$\therefore$ the mass it can lift is, $F = m * g$
$m = 141.39/9.81$
$m = 14.42$ kg

➔The pneumatic cylinder can lift a maximum of 14.42 kg

2. Base plate weight :
Material: Bakelite
Density = 1.3 kg/m^3
Volume of Base plate, $V = l * b * h$
$V = (0.3 * 0.175 * 0.008)$ m^3
$V = 4.2 * 10^{-4}$ m^3
Density, $\rho = \frac{m}{V}$
$m = \rho * V$
$m = 1.3 * 4.2 * 10^{-4}$
$m = 0.546$ kg

3. Gripper links weight :
Material: Mild Steel
Density = 7850 kg/m^3
Volume, $V = l * b * h$
$V = (0.71 * 0.03 * 0.005)$ m^3
$V = 1.065 * 10^{-4}$ kg
Density, $\rho = \frac{m}{V}$
$m = \rho * V$
$m = 7850 * 1.065 * 10^{-4}$
$m = 0.836$ kg

4. Connecting links weight :
Material: Mild Steel
Density = 7850 kg/m^3
Volume, $V = l * b * h$
$V = (0.13 * 0.02 * 0.005)$ m^3
$V = 1.3 * 10^{-5}$
Mass, $m = \rho * V$
$m = 7850 * 1.3 * 10^{-5}$
$m = 0.10205$ kg

5. Guide ways weight :
Material: Mild Steel
Density = 7850 kg/m^3
Volume, $V = \pi r^2 h$
$V = (3.142 * 0.005^2 * 0.39)$ m^3
$V = 3.06 * 10^{-5}$ m^3
Mass, $m = \rho * V$
$m = 7850 * 3.06 * 10^{-5}$
$m = 0.24$ kg

6. Connectors weight:
Material: Mild Steel
Density = 7850 kg/m^3
Volume, $V = l * b * h$
$V = (0.06 * 0.05 * 0.025)$ m^3
$V = 7.5 * 10^{-5}$ m^3
Mass, $m = \rho * V$
$m = 7850 * 7.5 * 10^{-5}$
$m = 0.59$ kg

5 ANALYSIS

After the theoretical calculations we proceeded to analyze the effects of force on the links through ANSYS software and we got the following results: -

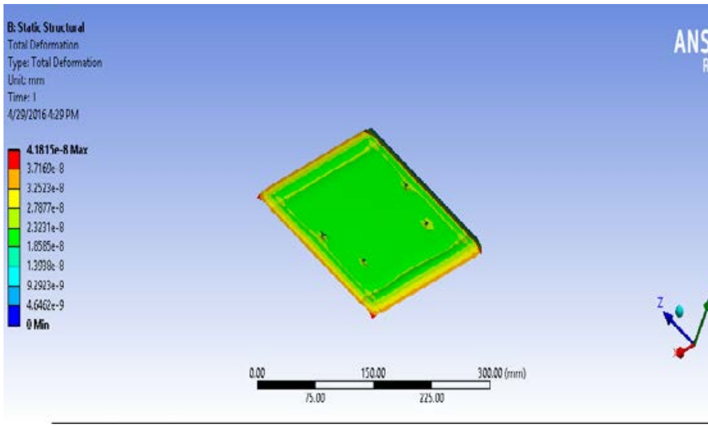

Fig.9 (baseplate deformation)

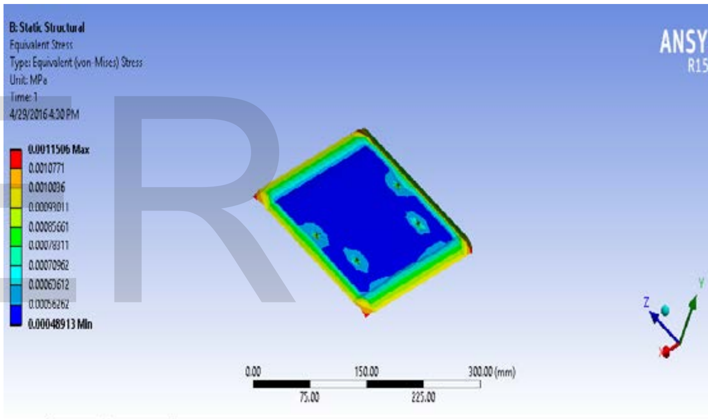

Fig.10 (baseplate stress)

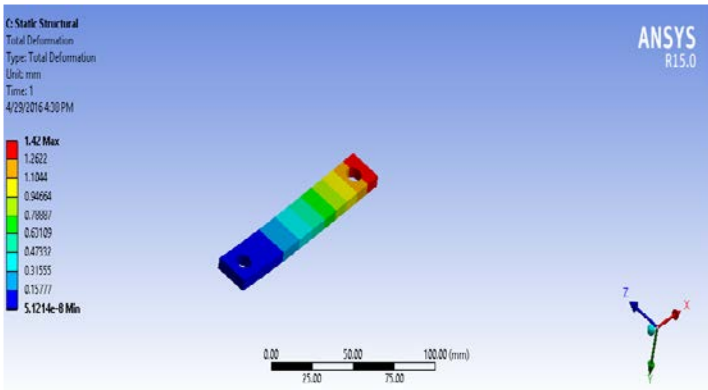

Fig.11 (link1 deformation)

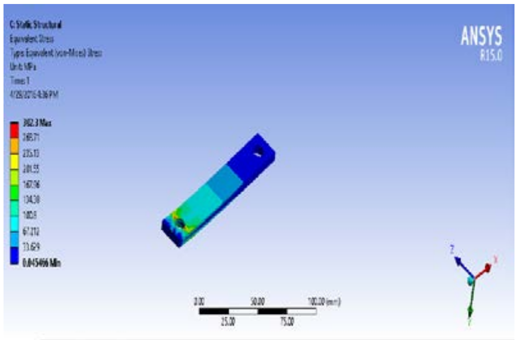

Fig.12 (link1 stress)

6 END SECTIONS

6.1 Conclusion

The design was done in SOLIDWORKS 2016 and the calculation were done and verified via SOLIDWORKS tests and ANSYS analysis. The design needed a few changes and improvements in practical application which were done and successfully implemented and the mechanism works and the robot is operational. We have decided to open source the design of the robot in case anyone wants to refer to it and make improvements.

There is a huge scope for development and improvement in the design. Firstly the design has a lot of constraints such as, the robot can only climb straight trees. Secondly the material used is mild steel which can be replaced either by aluminium or Bakelite which are light weight as well as strong.

The bot is already being controlled through mobile, using Bluetooth module and microcontroller used is Arduino NANO, we can still add more sensors for example to detect the coconut we can add a camera and use image processing etc.

This robot is a semi-autonomous robot but in the future can be made completely autonomous.

6.2 Acknowledgment

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7References

[1] Mani A, Jothilingam A, "Design and Fabrication of Coconut Harvesting Robot: COCOBOT", International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Special Issue 3, March 2014.

[2]M. Rajesh Kannan, P. Thejus, P. Allan, V. Trayesh, M. Gokul, "Robotic Arm Design for Coconut-Tree Climbing Robot", Applied Mechanics and Materials, Vol. 786, pp. 328-333, 2015

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