Semi-Autonomous Coconut Harvesting Robot

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Abstract*:* Our project paper is mainly based on the design and development of a coconut tree climbing robot and to empower mankind to hostile environment. Goal of the project is to design an economic and reliable coconut tree climbing robot for farmers since it is very difficult to climb a coconut tree and harvest it manually due to its cylindrical structure and single stem. Our robot is inspired by the inch worm mechanism for climbing the tree. It is a challenging task as the shape of tree is irregular and hence the robot uses a well balanced mechanical design so that it can climb tree. The continuum body is used for inchworm algorithm which can toggle its position between 'C' and 'I' shape to climb on the bent trees without any difficulty. The coconuts on the trees are cut down by the help of cutting arm, which is placed on the top gripper. The cutting arm is provided with 2 degree of freedom, which can be controlled flexibly by the user.

Keywords*: Continuum body, Top gripper, Bottom gripper, Arduino, cutting arm.*

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I. INTRODUCTION

Since agriculture being the backbone of India, faces a dreadful situation. One of the main problems is finding an unskilled labour to work in farms. Coconut harvesting remains a difficult job, due to its risk involved. Unfortunately despite its mass distribution and wide spread around the world, coconut harvesting is still done without proper safety measures which can lead to serious casualties. We have taken into account the safety, reliability, the ease of use which is capable of climbing trees, cutting down coconuts, cleaning the tree tops[6] [10] [1] [12]. Usually all over the country, farmers practice conventional harvesting method in which coconuts are picked by specially trained, skillful and experienced climbers.

The scope of this project is to climb a matured coconut trees having average diameter of 45cm therefore, maintaining sufficient friction force capable of handling the self-weight, maintaining the stability of the structure while in motion [3], reducing the total weight, and achieving the precise gripping is the important parameter that have to be considered. The continuum body is used for flexible motion [3]. Knife sickle or iron hook attached to the plucking end of long bamboo poles are also used for picking coconuts [13]. Coconuts have to be plucked once every 45 days and those who own the trees are finding it increasingly difficult to find professional climbers.

The robot works on three sub-mechanisms: (a) Gripping (b) Climbing and (c) Cutting. The machine is like an ape climbing the tree [3] [8]. First, the upper pair of arm grips the tree then the body moves up then the lower pair of arms grip the tree then the upper pair leaves the contact and the body moves up[2] [9]. With the appropriate equipment, our robot could assist workers to perform arboriculture tasks such as inspection and maintenance of coconut trees.

The paper is organized as follows Section II describes the mechanical design and mechanism of the robot. In Section III, the motion of the robot is described. The working of the robot and the algorithm of its operation is introduced in Section IV while applications of the robot in Section V and the future enhancements are given in section VI. Finally, conclusion is given in Section VII.

II. MECHANICAL DESIGN

The robot structure is mainly composed of four parts.

1) Top Gripper,

2) Continuum body,

3) Bottom Gripper,

4) Cutting arm.

Two grippers are connected to the ends of the continuum body. The gripper is designed for fastening on a tree surface. The locomotion of Tree bot is similar to an inchworm, changes its position from 'C' to 'I' and 'I' to 'C' to drag itself upwards and downwards

1. Top gripper and Bottom gripper

The main job of the gripper is to bring adhesive force between the robot and tree. The gripper is made of aluminum as shown in figure 1 and is designed in a way that for any diameter of the coconut tree the gripper makes contact in four places. For adhesive force we may use vacuum suction, hydraulics etc. But these types are only suited for plain surfaces like wall and glass. But the nature of tree surface is totally different, which are having irregular surface. This rubber is over a aluminum rod, this provides a better solution to the pressure handling during gripping. Once the top gripper is fixed the bottom gripper is freed and which moved and changes its position to ‘C’ shape. Then bottom gripper will fixed and top gripper moves upward, changes its position to ‘I’.

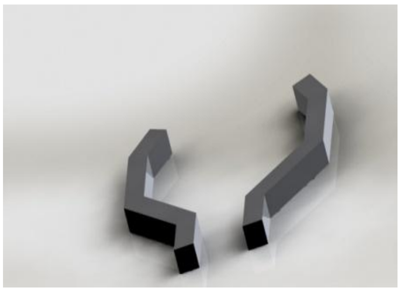


Figure 1-Gripper

The different features of the gripper section are the following:

1) Compact and light weight

2) Adaptive to irregular shape-This feature is achieved as each gripper is actuated by individual motors

3) Dose not leaves marks on the tree since the edges are covered by rubber

2. Cutting arm

The cutting arm is used to cut the required coconut branch. In order to achieve the cutting process a robotic arm is fixed on the top of the gripper. The cutting arm is provided with 2 DOF(degree of freedom) and spinning blade is used along with the body. The cutting arm is controlled by the user. Servo motors are used to guide a spinning blade towards the coconut branch. The figure 2 shows the cutting arm in upright position with its blade on its edge.

Figure 2-Cutting arm

3. Continuum body

This section is the most important section of the proposed design. The function of the continuum body is used to move the robot upward and downward direction. The continuum body is extendable and bendable and is made up of 2 bendable parts. The servo motor is connected at the two bendable parts, so that the grippers can either move upwards or downward.

The CAD diagram shown in figure 3 represents a fully assembled robot in 'C' structure, the figure also includes the gripper and cutting arm. The continuum body is also made of aluminum since it is lighter and strong.

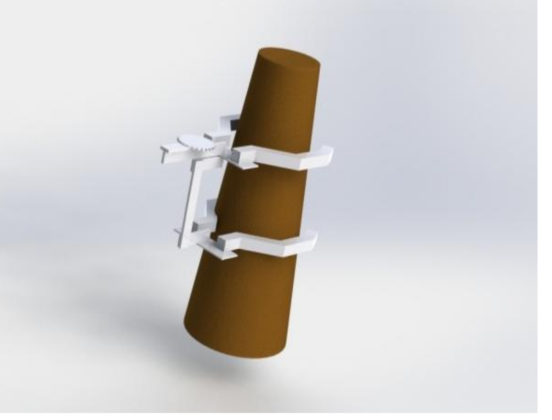


Figure 3-'C' Structure

The CAD diagram shown in figure 4 represents a fully assembled robot in 'I' structure, in this position the robot is in its full length.

Figure 4-'I' Structure

Microcontroller controls all the servomotors which are connected to four major sections; the motor which is used for cutting has a control circuit which is controlled by arduino microcontroller. The control box will be used to the control the robot, this box will be given to the user to instruct the robot.

The power source for the robot comes from a battery (7.5Ah/ 12v DC) which will be placed on ground to avoid unnecessary weight on robot.

III. Motion of Robot

The continuum body of the robot is designed in a smart way to adapt itself for any bending nature of the tree. The body changes its structure from ‘C’ to ‘I’ and ‘I’ to ‘C’ to drag itself upwards and downwards. The figure 5 and figure 6 shows the continuum body adapting itself to 'C' and 'I' struct

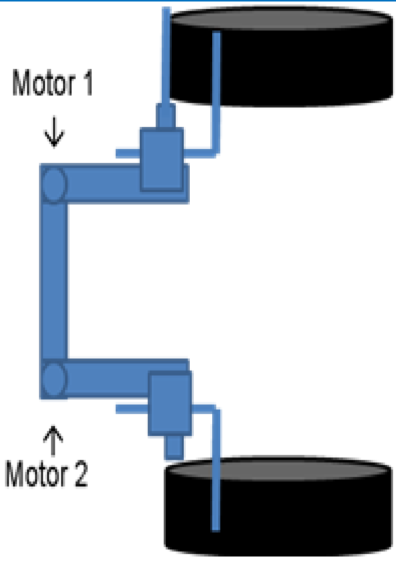


Figure 5- Contracted continuum body

The following figure represents a 'C' shape body where the maximum length of the robot is achieved

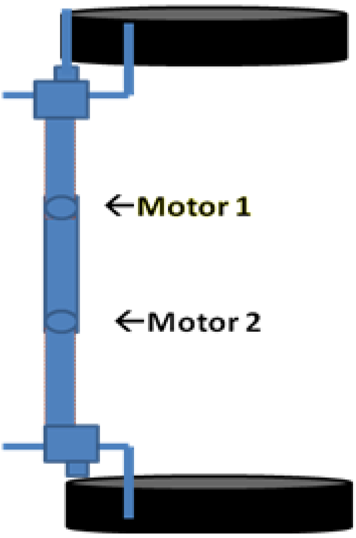


Figure 6- Expanded continuum body

IV. WORKING OF ROBOT

The proposed design of the robot is being controlled using a Arduino Mega (Atmega 2560) microcontroller and the software used is Arduino IDE. This microcontroller has the following features:

1. It has 54 digital input/output pins.
2. Equipped with 15 pulse-width modulation (PWM) pins.
3. There are 16 analog pins.
4. It works with 8kb of RAM and 256kb of flash memory.

The robot designed is made to follow the following algorithm to move it in an efficient manner. Limit switches are used to detect if the claws of the gripper have gripped on to the tree or have released the tree. The explanation of the working robot along with the limit switch action is as shown in the flowchart in Fig.7. The master control to the robot i.e. giving higher level commands like instructing when to stop the robot motion and when to reverse motion of the robot is instructed by the user. The following algorithm describes the working of the robot.

The figure 7 shows the flow chart for the main loop from where the control is shifted to climbing action loop (Figure 8) and cutting action loop (Figure 9).

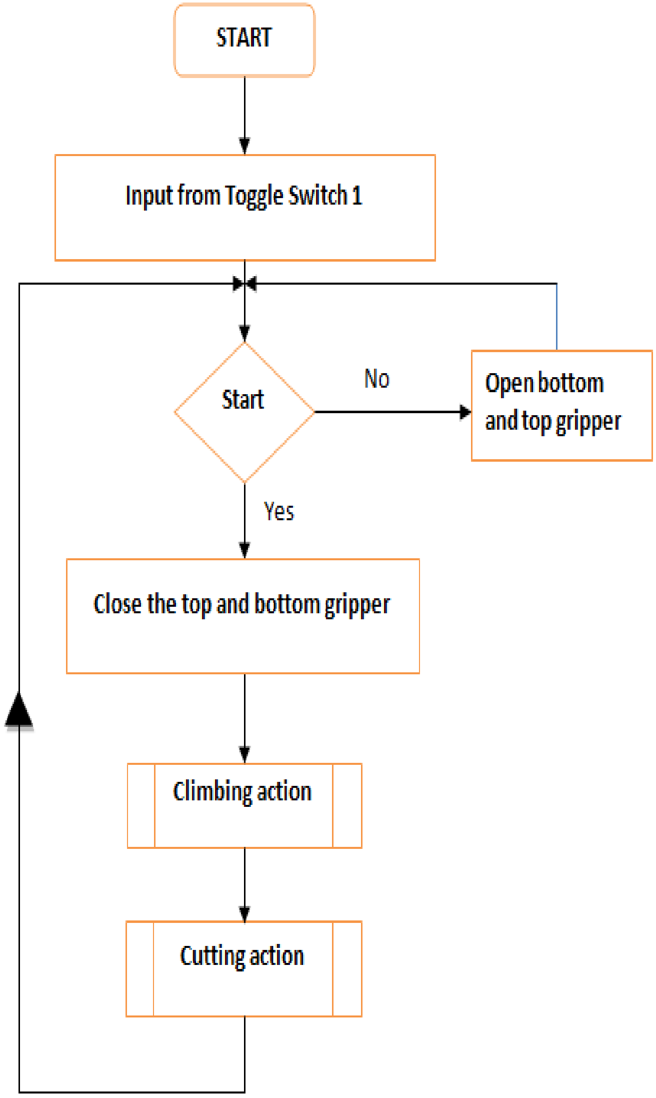


Figure 7- Flowchart for main loop

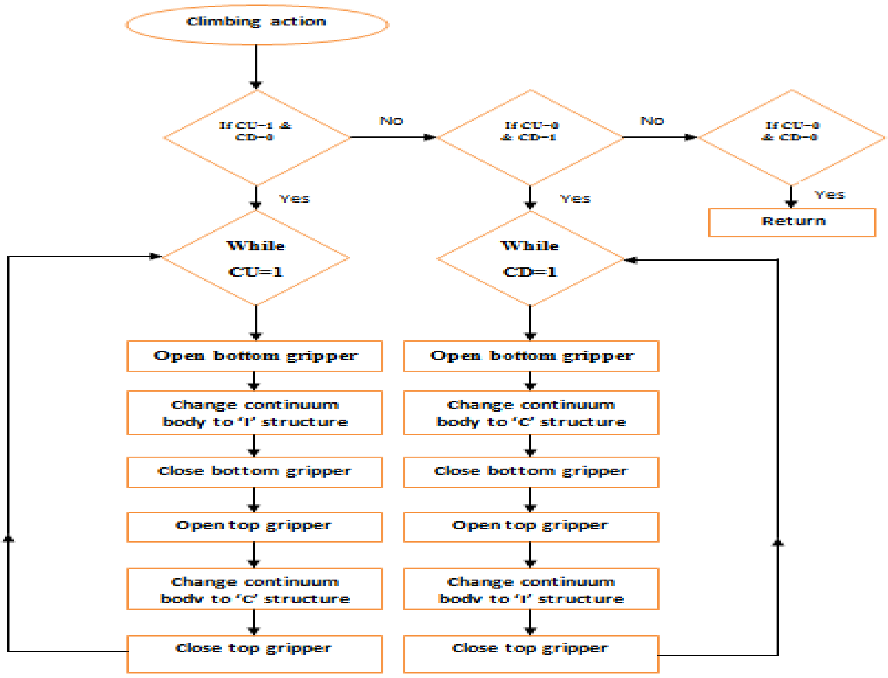


Figure 8- Flowchart for climbing action

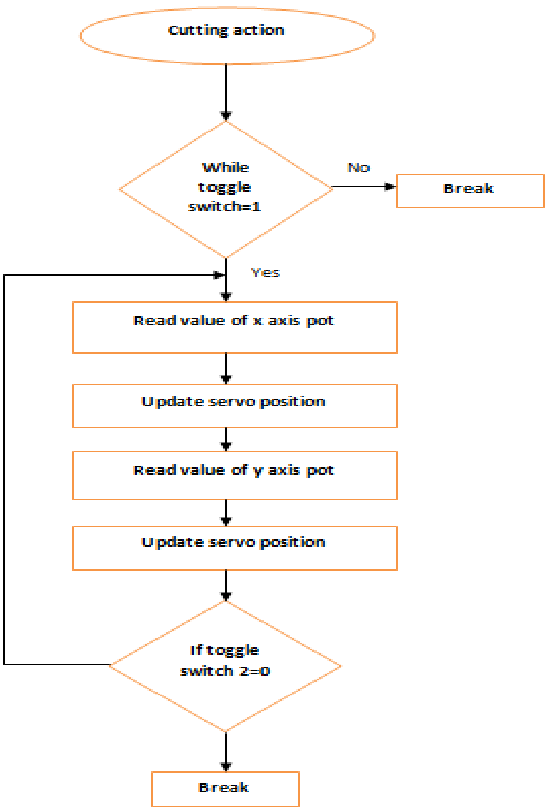
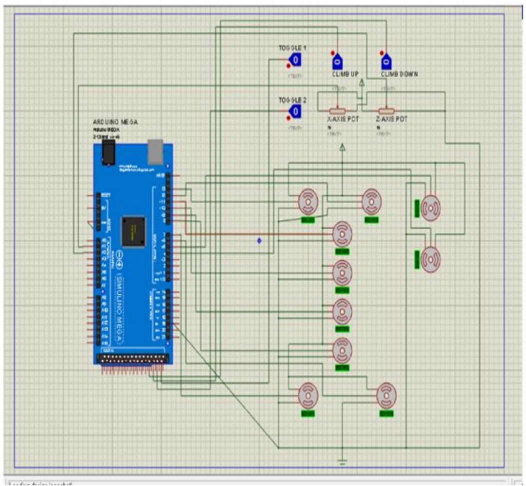


Figure 9- Flowchart for cutting action

The following figure shows the stimulation for the above flowchart using Proteus, the figure shows servo motors and logic outputs connected to Arduino Mega.

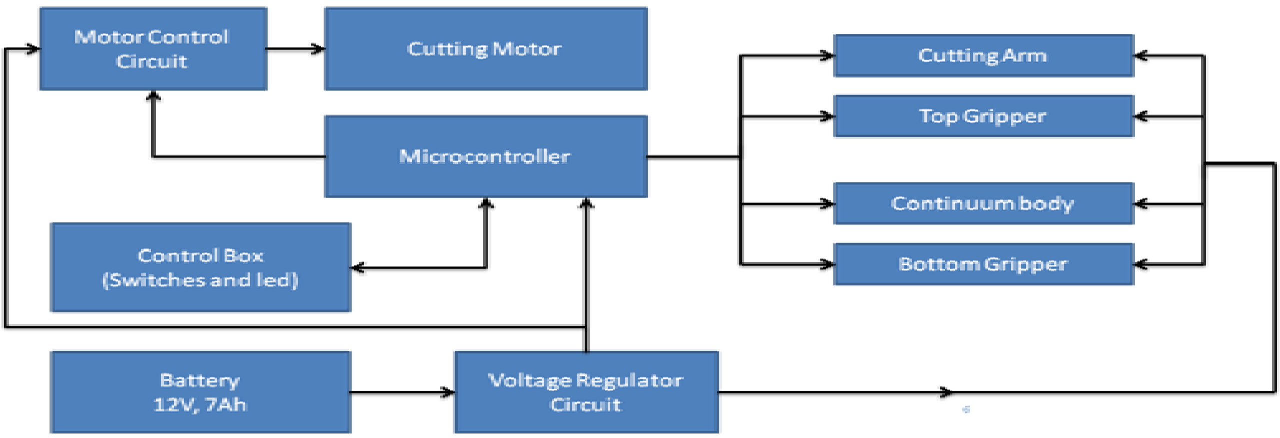


V. BLOCK DIAGRAM OF THE SYSTEM

The main parts are motor control circuit, cutting motor, microcontroller, cutting arm, top gripper, continuum body, bottom gripper, control box, battery, and voltage regulator. From the battery (12v, 7.5 ah) is delivered to the voltage regulator circuit. The voltage regulator will divides the power and send appropriate power for the motor control circuit, microcontroller and mechanical part.

From the control box the operating commands are send to microcontroller with the help of switch(toggle & push button). The microcontroller controls all the parts according to the condition given by the user.

BLOCK DIAGRAM



VI. FUTURE ENHANCEMENTS

- Robot can be developed to explore and climb on irregularly shaped trees with branches.
- It can be designed to be more intelligent with increased locomotory speed.
- The robot can be made multi terrained i.e. to climb walls, trees etc. depending on the requirement just by altering the gripping mechanism.
- The control can be made wireless by using Zigbee or other medium of communication

VII. CONCLUSION

In this paper, a novel tree climbing robot is presented that the maneuverability surpasses the state of the art tree climbing robots. It is composed of a pair of Omni-directional tree grippers for holding the robot on a tree surface and a novel 4 DOF continuum manipulator for maneuvering. The locomotion and workspace of the robot are also discussed. This also explains the algorithm used by the robot to climb the coconut tree and harvest the coconut trees. Thus this machine will reduce the tiring job of farmers and make the work much more economical.

The robot now works as a semi autonomous robot; the blades still have to be guided by the user instructions. Hence our future idea of implementing image sensing will make the robot completely autonomous and much more easy to use.

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