

## Integration of Haptics in Agricultural Robotics

**Rajesh Kannan Megalingam, Sreekanth M M, Vinu Sivanantham, K Sai Kumar, Sriharsha Ghanta, P Surya Teja, Rajesh G Reddy**

Dept. of Electronics and Communication Engineering, Amrita School of Engineering, Amritapuri

Amrita Vishwa Vidyapeetham, Amrita University, Kollam, Kerala

**Abstract:** Robots can differentiate with open loop system and closed loop system robots. We face many problems when we do not have a feedback from robots. In this research paper, we are discussing all possibilities to achieve complete closed loop system for Multiple-DOF Robotic Arm, which is used in a coconut tree climbing and cutting robot by introducing a Haptic device. We are working on various sensors like tactile, vibration, force and proximity sensors for getting feedback. For monitoring the robotic arm achieved by graphical user interference software which simulates the working of the robotic arm, send the feedback of all the real time analog values which are produced by various sensors and provide real-time graphs for estimate the efficiency of the Robot.

Keywords: agricultural robotics, force feedback, haptics.

### 1. INTRODUCTION

Nowadays more researchers are working on Haptics technology. Haptics which provide the sensory feeling between the robot and human when the robot interaction which involves in touch. Haptics fulfill the gap between robot and the user. Starting from touch screen mobiles, industrial, military and medical purposes there is a broad range of applications of haptic devices. For example, the surgeon can do the operation with the haptic device in a most efficient way by providing various sensor values and also can monitor through the system. In this paper, we discuss some simple mechanism to make Multiple-DOF Robotic Arm closed loop system and how to get feedback in all best possible ways by various sensors and how to store and monitor its feedback signals by Graphical User Interface.

### 2. PROBLEM STATEMENT

As of now, we have a robotic arm with the open loop control system; that is, it operates without any feedback. There is always a risk that the motors will not have intended effect and we will not get any information about the robotic arm during the cutting of leaves or coconut.



Our present model does not have any automation it is fully manual system, so it lacks accuracy in cutting. Due to this, a user who is controlling the arm does not know how much force has to be applied. So to cut the coconut, the user does not get any information about the arm whether it is stuck between the branches or not and the arm is moving towards the desired position or not.

To avoid these problems, the current robotic arm should be converted to a closed loop system. Converting to a closed loop system means implementing feedback for the arm. Once we get the feedback, the robotic arm can be fully automated. Accuracy and stability will be more than that of an open loop system. One way of achieving it is to develop a haptic device and control the robotic arm with the help of haptic feedback. Haptic feedback can be implemented with the aid of force sensors, vibration sensors, touch sensors and current sensors. Each of these sensors plays a vital role in improving the feedback of the system. Force sensor calculates the force acting on the arm and makes the user aware of the force with which the coconut should be cut. Vibration sensor gives vibration to the haptic device when there is any jerk or vibration in the robotic arm. Touch sensor gives a touch feel to the user handling haptic device when the arm touches any part of the tree. The current sensor gives the current drawn by the motor which helps in finding the load given to the motor.

### **3. RELATED WORKS**

Our system is a master-slave haptic robotic arm which used for agricultural purposes, like harvesting coconuts. Nowadays master-slave robotic arm systems are employed in many applications like clinical purposes, demining, exploration purposes and also for handling nuclear and toxic materials. Here we are using the master-slave haptic arm for agricultural uses. Most of the systems which used for the harvesting purpose are vision based. In the case of agricultural use, while harvesting the fruits, it should not damage the plant. In some situations, we need more force also. Our system is a touch based system which can give force feedback to the user, and we can give the exact force to the required point accurately.

There are systems for harvesting white asparagus without doing any damages to the plant [1]. The system uses fiber optic photoelectric sensors to decide the length of the plant. White asparagus grows below the ground level, and it has to be harvested before it grows beyond a particular height above ground level. It has a pneumatic gripper and cutting and collecting system. It uses a vision system consisting of two cameras to detect the plant. After detecting the plant, it approaches to the plant. Then it clears the dust using air spray. Then it cuts and collects the required part.

There is another system for harvesting the watermelon [2]. This robotic melon harvesting system has automatic modules for sensing and planning. It is also based on image processing principles. Locating the melon among the leaves is tough. The System uses the gray level image processing technique. While moving along a row, it selectively harvests the fruit. Proximity sensors are used to detect the ground levels, and size of fruit decides whether it is ripe or not. Robotic arm with proximity sensor grips the melon and two knives on arms cuts the fruit.

Another paper discusses tomato harvesting using robots [3]. To select tomato, they use vision technology and grippers with air-filled sacks. Information from the image is used to decide

whether it is ripe or not. Similarly, there is another system to harvest dates[4]. They use a ready-made robotic arm. Image processing is used to distinguish fruit and tree. To remove the leaves which cover the fruit the system use air jets. The robotic arm is a mobile part, and the system identifies the radius of the bunch, the horizontal distance between two bunches and distance between the bunches, to identify the target. All these arms are based on image processing principles, they are not giving any feedback to the user. The force feedback is necessary for harvesting coconuts. Since the harvesting has to be done at very height, the user gets more information for cutting the coconuts with correct force.

The use of force feedback is very rare in the agricultural field. There are some systems with force sensing to avoid damages to soft plant parts [5]. However, the user is not able to control the end effector of the robotic arm very accurately in that particular system. Our system includes two sections one is master, and another one is a slave. The slave is positioned to the exact position where we need to cut the fruit. We are using the system for harvesting coconuts. The bunches and branches of coconut trees are not in a deterministic manner, and the process is not repetitive. Moreover, we cannot control the growth of coconut trees for ease of harvesting. While the growth of some trees can be controlled to make the harvesting easier. Which means the proposed system will be an ideal one to harvest coconuts, in which we can monitor the end effector of the robotic arm accurately with force feedback. In one of our earlier works [6], a smart cane for the visually impaired people based on sound and touch, we discuss about the use of haptic modules for better experience. Haptic technology can be used to signal the users of this smart cane about the dynamic obstacles with the help of vibratory motors.

#### 4. SYSTEM ARCHITECTURE

The Haptic device is one that maintains the physical contact between the GUI and the user. The physical movement of the Haptic device provides input to the Haptics controller. This controller provides the motion information to GUI.

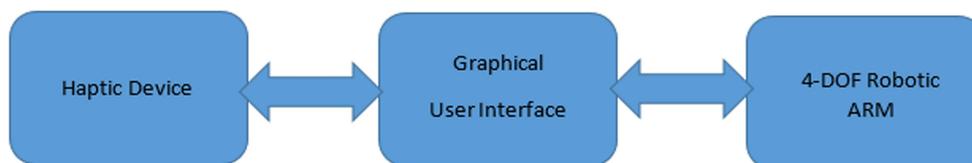


Fig. 1 General Block diagram.

Graphical User Interface (GUI), has an active display which resembles the real scenario of the Multiple-DOF Robotic Arm. Using communication protocol, GUI receives the sensor values as well as the position of the Multiple-DOF Robotic Arm. These position signals provide the information regarding the view, and sensor signals sent to the Haptic device for the real-time experience of the Multiple-DOF Robotic Arm. The Feedback system in the GUI helps to synchronize the animation view which controlled by the Haptic device and Robotic Arm.

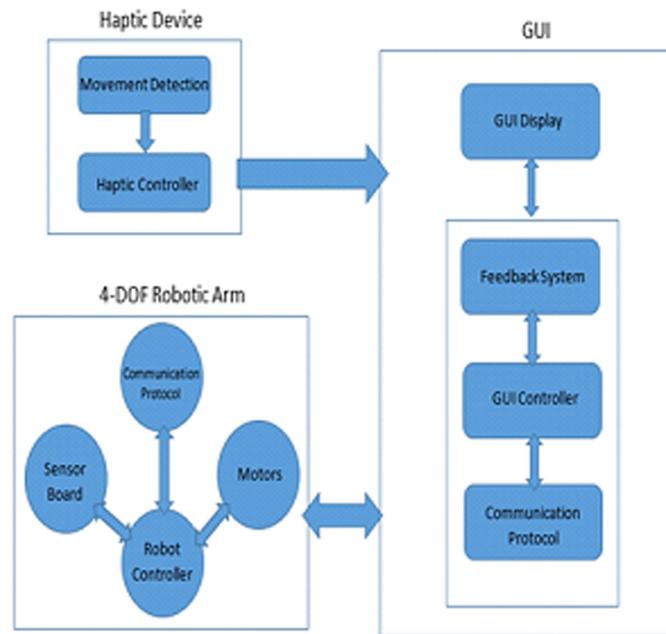


Fig. 2. Detailed Block diagram.

Multiple-DOF Robotic Arm equipped with various sensors like tactile, vibration, force and proximity sensors. These sensor values are processed using a Robotic controller. The communication protocol in Robotic Arm is used to communicate with GUI.

## 5. IMPLEMENTATION

Our system consisting of two sections. One is a master robotic arm, which the user can control very easily. And the other section is a slave robotic arm which will be harvesting the fruit from the tree. At each side to control the operations we have Arduino board which contains Atmega328 microcontroller. And for communication purpose we are using HC-05 Bluetooth module at both side.

Master part is a haptic device when we rotate each degree of freedom on it, we get a corresponding movement at slave part. The rotary encoders placed at each joint of the arm will be measuring how much the arm moved. We are using potentiometers as rotary encoders. The output of potentiometers will be a value between 0 and 5 volt. This value we are giving to analog input pins of master Arduino. The Arduino has a 10 bit analog to digital converter within it. So we get 0 to 1023 values corresponding to 0 to 5 volt. This value we are mapping to servo angle values and then we transmit the corresponding servo values to the slave side through a Bluetooth module.

The Bluetooth module which we are using is HC-05 which is having two operation modes one is Command mode and the other one is data transmission mode. While using two Bluetooth modules for communication one should be configured as master and the other one should be configured as slave. To configure the Bluetooth module as master and slave we put Bluetooth module in command mode and using AT command inputs we configure it as master and slave. To enable security to the operation we can also put a name and password to the module so that the device will not get paired with any other Bluetooth device. All these configurations will be done after putting the module in command mode. During the time of normal operation we have to put the module in data transmission mode.

When the Bluetooth module at the slave part receives the corresponding position values the servo motors attached at each links will start operating to reach exact position. Which means the slave operates simultaneously with the master. One of the main problem with the fruit harvesting especially coconut harvesting is the positioning of the end effector. Since our target will be at very height and will be covered with the leaves it will be very difficult to position the end effector. With this system the user can position as he want, while in conventional remote controlled systems it will be very difficult to do the same by controlling each link.

Along with the harvesting operations the sensors attached at the slave side will be continuously measuring some force parameters acting on the arm. The measured values will get transmitted through Bluetooth module. At the master side actuators like vibration motors will be giving exact force feedback to the user. So that the user can identify what is happening at harvesting side which is not clearly visible to the user.

## **6. FUTURE WORK**

Now the System consisting of one master haptic device with set of rotary encoders at each joint of the arm and we have a slave robotic fruit harvester that mimics the movement of master. And we have some set of sensors that measures some parameters at master side and system will give some feedback at slave side, so that the system will be more user friendly. In future we want to develop a software which will be coordinating the entire operation and user can see what is happening exactly at slave side. And we are planning to put more sensor arrays to get exact feedback.

## **7. CONCLUSION**

A Haptic device with provided communication protocol and GUI simulation allows minimizing the distance between the user and the robot. By obtaining feedback from robotic arm and simulation in GUI, we can achieve high accuracy in harvesting the coconuts, and by continuously monitoring the graphs we can estimate the efficiency of the robot while harvesting. In this paper we are presenting a basic approach of using haptics in agricultural robotics applications.

### ACKNOWLEDGMENT

We are grateful to Humanitarian Technology Labs (HuT Labs) of Electronics and Communication department of Amrita School of Engineering, Amrita Vishwa Vidyapeetham Univeristy, Amritapuri campus, Kollam, India for providing us all the necessary lab facilities and support towards the successful completion of the project.

### REFERENCES

- [1] Anna P. Chatzimichali, Ioannis P. Georgilas and Vassilios D. Tourassis, “ Design of advanced prototype robot for white asparagus harvesting,” International Conference on Advanced Intelligent Mechatronics Suntec Convention and Exhibition Center Singapore, July 14-17, 2009.
- [2] Yael Edan, Member, IEEE, Dima Rogozin, Tamar Flash, and Gaines E. Miles, “Robotic Melon Harvesting ,” IEEE Trans. Robotics and Automation.,vol. 16, no. 6, December 2000.
- [3] Qingchun Feng,Xiaonan Wang, Guohua Wang, Zhen Li, “Design and Test of Tomatoes Harvesting Robot,” IEEE International Conference on Information and Automation Lijiang, China, August 2015 .
- [4] A. A. Aljanobi, S. A. Al-hamed, and S. A. Al-Suhaibani, “A Setup of Mobile Robotic Unit for Fruit Harvesting,”International Workshop on Robotics in Alpe-Adria-Danube Region,Budapest, Hungary June 23–25, 2010.
- [5] Christoph Schuetz, Julian Pfaff, Felix Sygulla, Daniel Rixen and Heinz Ulbrich, “Motion Planning for Redundant Manipulators in Uncertain Environments based on Tactile Feedback,” IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) Congress Center Hamburg, Germany, Sept 28 - Oct 2, 2015.
- [6] Megalingam, R.K., Nambissan, A., Thambi, A., Gopinath, A., Nandakumar, M., “Sound and touch based smart cane: Better walking experience for visually challenged”, 2014 IEEE Canada International Humanitarian Technology Conference, IHTC 2014, DOI: 10.1109/IHTC.2014.7147543



**Dr. Rajesh Kannan Megalingam**, is the Director of HuT labs, Amrita Vishwa Vidyapeetham University, India, heading research in Agricultural Robotics and Rehabilitation Robotics. He had is PhD and Masters from the same university. He has several publications in international conferences, journals and two book chapters to his credit.



**Mr. Sreekanth M M**, is currently in the final year of his Masters in Amrita Vishwa Vidyapeetham University, India doing his MTech VLSI in ECE dept. He is also working as Research Assistant at HuT Labs



**Mr. Vinu Sivanantham**, is currently in the final year of his bachelors in Amrita Vishwa Vidyapeetham University, India doing his BTech in ECE dept. He is also working as Jr. Research Assistant at HuT Labs



**Mr. Sri Harsha Ghanta**, is currently in the final year of his bachelors in Amrita Vishwa Vidyapeetham University, India doing his BTech in ECE dept. He is also working as Jr. Research Assistant at HuT Labs



**Mr. Kotte Sai Kumar**, is currently in the final year of his bachelors in Amrita Vishwa Vidyapeetham University, India doing his BTech in ECE dept. He is also working as Jr. Research Assistant at HuT Labs



**Mr. Surya Teja**, is currently in the final year of his bachelors in Amrita Vishwa Vidyapeetham University, India doing his BTech in ECE dept. He is also working as Jr. Research Assistant at HuT Labs



**Mr. Rajesh G**, is currently in the final year of his bachelors in Amrita Vishwa Vidyapeetham University, India doing his BTech in ECE dept. He is also working as Jr. Research Assistant at HuT Labs