Teleoperation of Robotic Arm Using Leap motion Controller

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Abstract

The field of robotics has undergone tremendous advancement in recent times. Today, robots are not only expected to be precise and durable but their capabilities are expected to resemble those of humans as closely as possible. In our project, we plan to implement a novel and intuitive human-robot interaction system based on a Leap Motion sensor and a robotic arm. This will enable a more natural human-robot interaction of the robotic arm and will also ensure smooth and efficient manipulation. Hence, our study will discuss and demonstrate how a human can interact with a robot through simple hand gestures. We intend to build a working prototype of the system by the end of the project.

1. Introduction and Motivation

The project selected is based on today's growing market for smart robotic applications. There is a pressing need to incorporate a wide variety of sensors in a robotic system in order to enable robots to perform in a diverse array of applications. For e.g., computer vision can be exploited to help the robot to "see" and recognize objects in the same way as a human would.

Our project mainly focuses on controlling a robotic arm which would imitate the actions of a human hand. This will be achieved using a Leap Motion sensor device which would help us to map human actions into the movement of the joints of the robotic arm.

2. Related Work

There are several related projects that we can examine that involve the combination of a robotic arm and Leap Motion sensor. One such project included the use of a Jaco robotic arm with 6-DOF for applications in "AAL", or Ambient Assisted Living, to assist the elderly and handicapped. During the development of their project, they had incorporated a method to ignore hand tremors through the use of a threshold value set during the calibration process [1]. Another project made use of a Kinect sensor instead of Leap Motion to control a 7-DOF Baxter robot. Similar to the Leap Motion sensor, the Kinect sensor was used to detect hand movement along with body motion to control the robot. They had tested two different approaches: a vector approach and an inverse kinematics approach [8]. Instead of a Leap Motion sensor, another project using the Baxter robot used the SensAble haptic device which incorporated the use of a haptic feedback sensor [4]. This allowed the user to actually sense the robot's movement.

3. Problem Statement

A. System Description

The system consists of the hand tracking device (Leap Motion controller) and a robot with dual arms. Hand tracking is done with Leap motion device and processing software will be used to retrieve the position data from the tracking sensor. The hand (finger) position data will be translated into joint angles by inverse kinematics (mapping algorithm). The robot arm will be operated by the known joint angles in real-time. We are yet to finalize the robot, however, we have shortlisted a few and will be taking the decision on the robot soon.

B. System principle

Many software are capable of interfacing the Leap motion with a PC, e.g. Node, Processing. In our project, the software will be used to extract skeleton data of hand which will then be analyzed and filtered using computer vision/object recognition algorithms and classifiers. The filtered data will be fed into the movement algorithms to calculate the each joint angle. The structure and the flow of the system are shown in the block diagram.

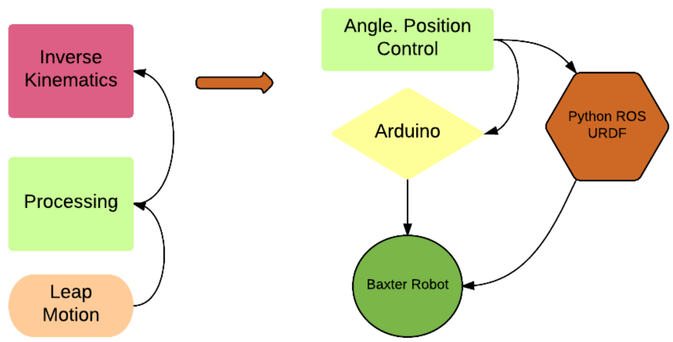


Figure 1: Principle of teleoperation control with leap motion

C. Leap Motion Controller

The Leap Motion sensor is an advanced motion sensor that will be used to capture the movement of the human hand. It uses a combination of two cameras and three infrared LEDs to observe an area roughly the shape of a hemisphere with a radius of 1 meter. It is considered to be a breakthrough in the field of human-computer interaction through hand gestures as it is the first consumer grade controller that introduces novel gesture recognition and position tracking with sub-millimeter accuracy. Using this Leap Motion sensor, a set of relevant hand points (e.g. Hand palm position, Finger tips, Roll, Pitch, Yaw) and some hand pose features will be gathered through the human hand present in the frame of the sensor.

4. Evaluation Metrics in the Project:

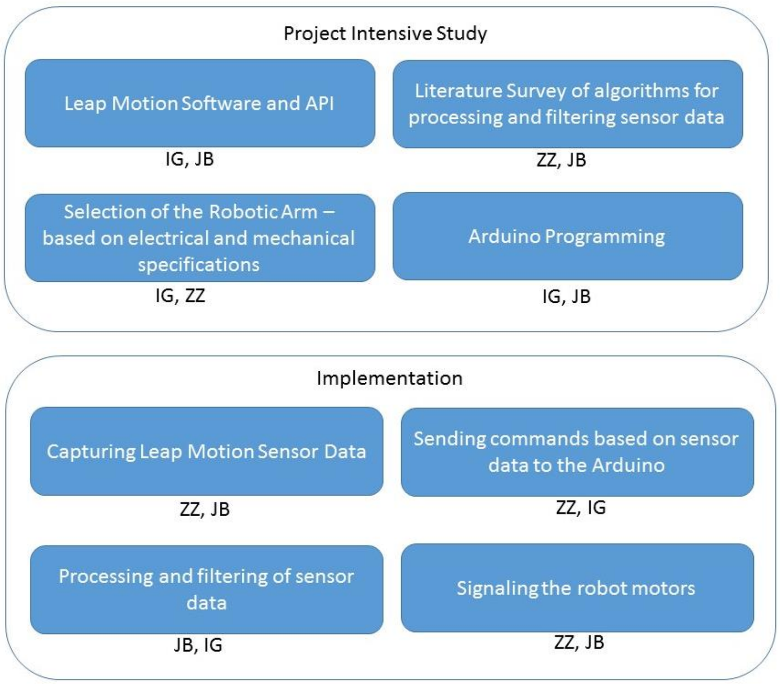
1. Features extracted by the sensor and their accuracy with respect to the actual movements of the human hand.
2. Accuracy of the arm, i.e. examining how closely the robotic arm movement resembles the motion of the human hand, in terms of rotation and translation.
3. Latency of the robotic system – the time from the movement of the hand up until the robot starts the same movement.
4. Variation in the shape, size and weight of the objects being handled by the robot.

5. Deliverables

1. A demonstration of the working robotic system
2. Final report and presentation.
    a. Report on accuracy and precision of Leap Motion sensor data.
    b. Statistics about the latency and accuracy of the robotic system.
    c. A report detailing the various kinds of objects successfully manipulated by the robotic arm.

d. Scenario where the robot failed to successfully perform the task.
e. Possible future work – improvements and applications.

6. Work Plan



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7. Key Requirements for the project:

1. Robotic Arm with battery/DC power supply
2. Leap Motion device
3. Arduino (ROS or URDF)
4. Mechanical and electrical tools for tweaking the robotic arm

8. Project Milestones

Sl. No.	Stages of the project	Weeks											
		1	2	3	4	5	6	7	8	9	10	11	12
		09/28 10/04	10/05 10/11	10/12 10/18	10/19 10/25	10/26 11/01	11/02 11/08	11/09 11/15	11/16 11/22	11/23 11/29	11/30 12/06	12/07 12/13	12/14 12/20
1	**Literature Survey & Learning Phase**												
1.1	Project intensive study	■	■										
1.2	Study of tools & Leap Motion SDK		■	■									
2	**Implementation**												
2.1	Leap Motion software development			■	■	■	■	■					
2.2	Mechanical work on the robotic arm				■	■	■	■	■				
2.3	Arduino programming					■	■	■					
2.4	Interfacing Arduino with robotic arm						■	■	■	■			
2.5	Interfacing Arduino with PC and Leap Motion							■	■	■	■		
3	**Results & Analysis**												
3.1	Testing and debugging									■	■	■	
3.2	Statistics to evaluate performance									■	■	■	
4	**Final project report and presentation**											■	■

9. Future goals:

In case we are able to achieve the aforementioned goals ahead of time, the following is some of the future work planned.

1. Increasing the number of fingers from two in order to manipulate objects of varying shapes (like Jaco robotic arm)
2. Adding haptic feedback to the system to provide the operator with a tactile feeling of remote environment through the force feedback.

10. References:

1. Bassily, David, et al. "Intuitive and adaptive robotic arm manipulation using the leap motion controller." *ISR/Robotik 2014; 41st International Symposium on Robotics; Proceedings of*. VDE, 2014.
2. Fitzgerald, Conor. "Developing baxter." *Technologies for Practical Robot Applications (TePRA), 2013 IEEE International Conference on*. IEEE, 2013.
3. Ju, Zhangfeng, Chenguang Yang, and Hongbin Ma. "Kinematics modeling and experimental verification of baxter robot." *Control Conference (CCC), 2014 33rd Chinese*. IEEE, 2014.
4. Ju, Zhangfeng, et al. "Teleoperation of humanoid baxter robot using haptic feedback." *Multisensor Fusion and Information Integration for Intelligent Systems (MFI), 2014 International Conference on*. IEEE, 2014.
5. Leap Motion | Mac & PC Motion Controller for Games, Design, & More. 2014. Available at: http://www.leapmotion.com. [Accessed January 2014].
6. Liu, YuKang, et al. "Predictive control for robot arm teleoperation." *Industrial Electronics Society, IECON 2013-39th Annual Conference of the IEEE*. IEEE, 2013.
7. Marin, Giulio, Fabio Dominio, and Pietro Zanuttigh. "Hand gesture recognition with leap motion and kinect devices." *Image Processing (ICIP), 2014 IEEE International Conference on*. IEEE, 2014.
8. Reddivari, Huli, et al. "Teleoperation control of Baxter robot using body motion tracking." *Multisensor Fusion and Information Integration for Intelligent Systems (MFI), 2014 International Conference on*. IEEE, 2014.
9. Vikram, Sharad, Lei Li, and Stuart Russell. "Handwriting and Gestures in the Air, Recognizing on the Fly." *Proceedings of the CHI*. Vol. 13. 2013.
10. Weichert, Frank, et al. "Analysis of the accuracy and robustness of the leap motion controller." *Sensors* 13.5 (2013): 6380-6393.