CONTACT FORCE ESTIMATION USING MOTOR CURRENTS OR TORQUES

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C014
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by

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Abstract

The abstract is a highly condensed version of the whole project. Its function is to draw the reader's attention to the main points or findings of the project. It should include: (a) (b) (c) (d) (e) A concise statement of the problem investigated, hardware to be designed, or software to be written Purpose of the project A concise description of how the information was collected, the design methodology or the software approach used in the project The results A concise summary of conclusions and recommendations. The ordering of the above varies according to the type of readers and the purpose of the report. The general rule is to start with information that is most important or interesting. This part of the report should be written only after the whole report is completed and not before. The abstract can be broken up into a small number of paragraphs but the length is usually limited to one A4 page. Single line spacing is allowed in the Abstract.

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Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 General Introduction

Nowadays, robotics play a very crucial role in industrial area by greatly increasing the industrial productivity. It helps factory workers on doing many monotonous and tedious taks such as pick and place and welding operation. However, this achievement is done because of a highly structured environment such as heavy industry (for example car assembly) where every parameters are known and fixed. In contrast, robotics performance in light industry are still poor. For instances, assembly of small and fragile parts in electronics, food, and other industries. This is because robotics are still bad in dealing with dynamics and unstructured environment where uncertainities are common.

In light of this, researches and developments in this topic are still intense until now. Many works have attempted to create a framework for fine assembly procedures. Recently, a paper by (?, ?) has introduced the complete framework for fine assembly task. However, there are still lots of improvement that can be done.

For robotic assembly task, the robotic arm must be able to cooperate with a lot of uncertainites in the dynamic environment. One example, the manipulator has to be able to know when the contact with an object is happening and then maintaining the stable contact throughout the task. This ability requires knowledge of contact force for the robot. Thus, estimation of contact forces is very important since it will help the robot to determine and control the contact with objects in dynamics environment. While this can be done using accurate

Figure 1.1: Put the figure here

Figure 1.2: Put the figure here

force/torque sensor, the sensor is normally expensive and requires mechanical integration with the robotic arm (Wahrburg, Morara, Cesari, Matthias, & Ding, 2015). Hence in some arms it might not be possible to attach this sensor.

In regards to this, many researches have been done in order to estimate the contact force. The main idea to estimate the contact force is to directly apply dynamic equations of a robot, knowing the value of joint torques. However different approaches have also been explored in the past few decades. Early approaches use observers for force estimation like in (Ohishi, Miyazaki, Fujita, & Ogino, 1991). Another approach in (Stolt, Linderoth, Robertsson, & Johansson, 2012) involves detune the low-level joint position control loop to estimate contact force. Furthermore, recent approaches by using Bayesian approach and generalized momentum with Kalman filter are studied in (Wahrburg, Zeiss, Matthias, & Ding, 2014) and (Wahrburg et al., 2015) respectively. Additionally, studies of comparison between two different approaches are done in (Damme et al., 2011). The study compares the result from filtered dynamic equation of external force with generalized momentum method.

1.2 Objective

This project aims to estimate the contact force of an assembly robot based on the arm motor currents/torques. Understanding of the mathematical model of the robots dynamic, friction, and control theory are considered as important knowledge to work with this project.

The project will be focusing on a certain Denso arm. Thus, the developed systems will be built specifically for this arm. Additionally, some problems that are discussed in this project will be only addressed for this Denso arm and might not be available for other arms.

1.3 Scope

The scope of this project is divided into four parts. First, the project will start from understanding of the general models of robot dynamic and friction. Thus, literature reviews and readings are included in this step. The next step is to perform some experiments to get all necessary data to develop the model. This includes setup preparations, running the experiments, and collections of the data. The third step will be processing all the results and develop the system to estimate the contact force. which after that, validation of the built model to the real data will be the final step.

Chapter 2

Literature Review

2.1 Background

2.2 Purpose and scope

1	2	3
4	5	6
7	8	9

Table 2.1: A simple table

Figure 2.1: NTU logo

First eref (Wahrburg et al., 2014) asdfsdf

Second (Damme et al., 2011) asfdasdf

Third (Bona & Indri, 2005) asfdsf

fourth (Ohishi et al., 1991)

Chapter 3

Mathematical Model

3.1 Background

3.2 Purpose and scope

1	2	3
4	5	6
7	8	9

Table 3.1: A simple table

Figure 3.1: NTU logo

First eref (Wahrburg et al., 2014) asdfsdf

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Third (Bona & Indri, 2005) asfdsf

fourth (Ohishi et al., 1991)

Chapter 4

Equipments

Necessary equipments, software, and robotic arm that are going to be used are: Denso VS060A3-AV6 arm, end-effector handle, ATI Gamma F/T Sensor (SI-32-2.5 calibration), Ubuntu 12.04 LTS, OpenRave, and Denso ROS.

4.1 Denso VS060

Denso VS060A3-AV6 is a six DOF robotic arm from Denso company. It has absolute encoder for all of its joint position. An RC-8 controller is also provided for interfacing with this arm. The computer is connected to Denso arm via LAN cable. The architecture of the hardware interface for this arm can be seen in figure below.

4.2 ATI Gamma F/T Sensor

This F/T Sensor is attached into the end-effector of Denso arm to measure the contact force and torque. After this sensor, another handle is attached on top of the F/T sensor. Hence, with the addition of contact force and torque, F/T sensor will also read the weight and inertial force from the handle.

4.3 End-effector handle

This is the handle of the end-effector arm. It has a round sphere surface. The arm will make a contact with environments through this handle.

4.4 Ubuntu 12.04 LTS

The OS of the working computer is Linux Ubuntu, with version of 12.04. It is not the attest version and it should stay in 12.04 version for operating the arm. Some important packages are also installed, they are OpenRave and Denso ROS. Python and C++ are used to run the Denso arm.

4.5 OpenRave

OpenRAVE is a package that provides an environment for testing, developing, and deploying motion planning algorithms in robotics applications. It focuses on the simulation analysis of motion planning. It is to be used together with Denso ROS to control the Denso arm with its analysis guidance. The OpenRave is oftenly used in Python script.

4.6 Denso ROS

Denso ROS is a robot operating system that works on the Denso arm. With Denso ROS, the manipulator arm can be controlled from computer. The packages are written in C++ and Python while the script to run the robot is usually written in Python codes.

Chapter 5

Methodology

5.1 Motor Currents Reading

Before continue with more experiment and identification, there is one problem that needs to be solved first. The problem is that the arm only gives absolute value of the motor currents (Fig. 5.1a). Thus there is a need to identify the sign of the motor currents of each joints. Three methods were tried but only one was successful.

The first attempt was to give the motor current sign based on the sign of τ_{dyn} during non-contact condition. However, this poses a problem when the τ_{dyn} goes near zero as it will not be clear enough to identify the sign. The second method was to match the derivative of motor currents with derivative τ_{dyn} during pre-contact motion (e.g.: if τ_{dyn} is increasing, the motor currents has to be increasing too, and vice versa). Unfortunately, this principle working only if motor currents are very smooth and steady which is a very difficult condition.

After the first two attempts, it was found out that we can actually extract motor torques value from Denso and this time it includes the sign of it. The data is then plotted against motor currents with the sign of motor torques to see the relation. From Fig. 5.2 we can see that there is a good linearity between these two variables, and so we can now actually use motor torques instead of motor currents. By doing this, not only we do not need to take care of the currents sign problem anymore, we also simplify our problem since what we are interested in is the motor torques, not motor currents. However, since the value is not in the SI unit calibration is needed to adjust the value into the SI unit.

(a) Raw data of motor currents

(b) Raw data of motor torques

Figure 5.1: Reading of motor currents

Figure 5.2: Motor torques vs motor currents with sign

5.2 High Torque Collection Data

5.3 High Velocity Collection Data

Chapter 6

Results and Model Identification

6.1 Background

6.2 Purpose and scope

1	2	3
4	5	6
7	8	9

Table 6.1: A simple table

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Chapter 7

Model Validations

7.1 Motor Currents Reading

7.2 Purpose and scope

1	2	3
4	5	6
7	8	9

Table 7.1: A simple table

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Chapter 8

Conclusion and Future Works

8.1 Background

8.2 Purpose and scope

1	2	3
4	5	6
7	8	9

Table 8.1: A simple table

Figure 8.1: NTU logo

First eref (Wahrburg et al., 2014) asdfsdf

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Third (Bona & Indri, 2005) asfdsf

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