UNIVERSITY OF VERONA

MASTER THESIS

Title . . .

Author:
Michele PENZO
VR439232

Supervisor:
Dr. Diego DALL'ALBA

ICE Lab
Department of Computer Science

December 24, 2020

UNIVERSITY OF VERONA

Abstract

Department of Computer Science

Master of Science

Title . . .

by Michele PENZO
VR439232

Abstract. . .

Acknowledgements

acknowledgements ...

Contents

Abstract **iii**

Acknowledgements **v**

Contents **vii**

List of Abbreviations **ix**

1 Introduction **1**
1.1 Motivations . . . 1
1.2 Goals . . . 1
1.3 Thesis Overview . . . 1

2 Theory overview **3**
2.1 About the robot . . . 3
2.2 Kinematic chains . . . 3
2.2.1 Types of Kinematic Chains . . . 3
Direct Kinematic . . . 3
Inverse Kinematic . . . 3
2.2.2 Denavit–Hartenberg Convention . . . 3
2.3 Theory about robot control . . . 3
2.3.1 Postion control . . . 3
2.3.2 Cartesian impedance control . . . 3
2.3.3 Joint impedance control . . . 3

3 Literature Review **5**
3.1 Robot learning from Demonstration . . . 5
3.1.1 Kinesthetic Teaching . . . 5
3.1.2 Teleoperation . . . 5
3.2 Assembling and modulable tasks . . . 5
3.2.1 Assembling tasks . . . 5
3.2.2 Modulable tasks . . . 5

4 The project **7**
4.1 Sunrise OS . . . 7
4.2 ROS . . . 7
4.2.1 IIWA stack . . . 7
4.3 Project implementation . . . 7
4.3.1 Theach by demonstration . . . 7
4.3.2 Teleoperation . . . 7

5 Experiments and Result **9**
5.1 Experiments . . . 9
5.2 Results . . . 9

6 Conclusion **11**
6.1 Conclusions 11
6.2 Other possible works 11

List of Abbreviations

LBR	**L**eicht **B**au **R**oboter
IIWA	**I**ntellingent **I**ndustrial **W**ork **A**ssistant
DOF	**D**egree **O**f **F**reedom
ROS	**R**obot **O**perating **S**ystem
HRI	**H**uman **R**obot **I**nteraction
HMI	**H**uman **M**achine **I**nterface

Chapter 1

Introduction

1.1 Motivations

1.2 Goals

1.3 Thesis Overview

Chapter 2

Theory overview

2.1 About the robot

2.2 Kinematic chains

2.2.1 Types of Kinematic Chains

Direct Kinematic

Inverse Kinematic

2.2.2 Denavit–Hartenberg Convention

2.3 Theory about robot control

2.3.1 Postion control

2.3.2 Cartesian impedance control

2.3.3 Joint impedance control

Chapter 3

Literature Review

3.1 Robot learning from Demonstration

3.1.1 Kinesthetic Teaching

3.1.2 Teleoperation

3.2 Assembling and modulable tasks

3.2.1 Assembling tasks

3.2.2 Modulable tasks

Chapter 4

The project

4.1 Sunrise OS

4.2 ROS

4.2.1 IIWA stack

4.3 Project implementation

4.3.1 Theach by demonstration

4.3.2 Teleoperation

Chapter 5

Experiments and Result

5.1 Experiments

5.2 Results

Chapter 6

Conclusion

6.1 Conclusions

6.2 Other possible works