

Institute of Automation and Robotics

Homework 1

in the subject of Modelling and control of manipulator

Derivation of the kinematic model of the ABB IRb-7600 manipulator

Munir Fati Haji

student record book number 323834

submitted to

**Mr. Maksym Figat.**

WARSAW 2022

**Table of Contents**

[List of abbreviations iii](#_Toc91984130)

[Step 1 – Putting the axes 1](#_Toc91984131)

[Step 2 - Denavit-Hartenberg(D-H) parameters 2](#_Toc91984132)

[Step 3 - Direct Kinematics Problem 2](#_Toc91984133)

[1. Joint/link description matrices 2](#_Toc91984134)

[2. Composition of matrices 2](#_Toc91984135)

[Step 4 - Inverse kinematic problem solution 5](#_Toc91984136)

[1. Solve as a function of given parameters 5](#_Toc91984137)

[2. Solve as a function of and given parameters 5](#_Toc91984138)

[3. Solve as a function of and given parameters 6](#_Toc91984139)

[4. Solve as a function of and given parameters 7](#_Toc91984140)

[5. Solve as a function of and given parameters 7](#_Toc91984141)

[6. Solve a function of and given parameters 7](#_Toc91984142)

[Conclusion 8](#_Toc91984143)

## List of abbreviations

Homework

Derive the kinematic model of the ABB IRb-7600 manipulator, i.e. solve the direct and inverse kinematic problem for that manipulator.

Diagram, engineering drawing

Description automatically generated

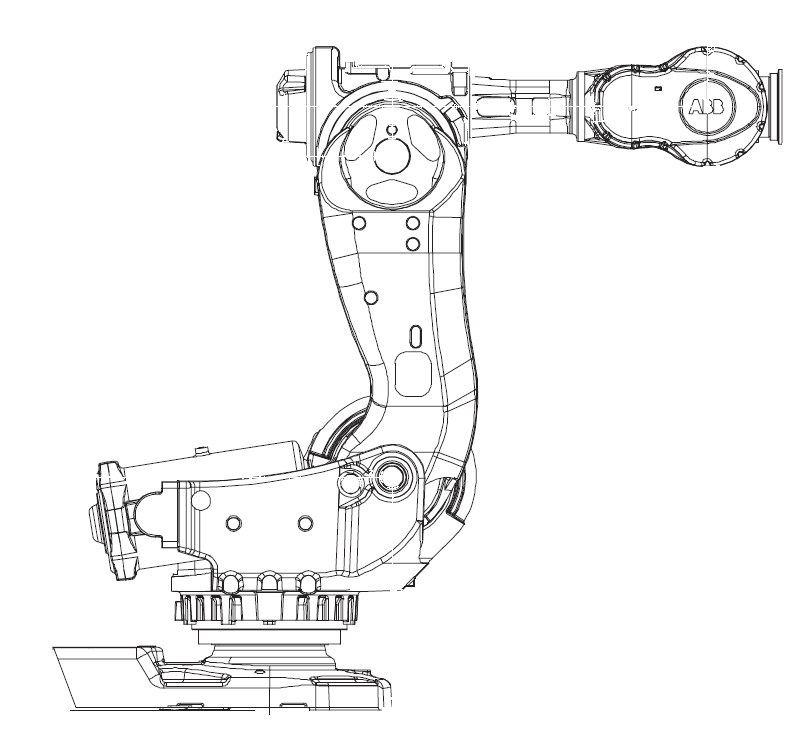
Figure 1 2D Drawing of the Model ABB IRb-7600 Manipulator

# Step 1 – Putting the axes

From lecture notes Algorithm producing the kinematic model of a manipulator has steps as follows

* Draw the manipulator
* Identify the axes of rotation or translation (for revolute and prismatic joints)
* Assign the axis to the axis of rotation/translation
* Find the common perpendiculars between the and axes (if those axes intersect the common perpendicular is defined along)
* Define the axes – the axis *i*−1*x* coincides with the common perpendicular between the and axes and points fromto
* Determine the axes
* The base coordinate frame 0 should be located in such a way that *α*0, *a*0 and *θ*1 or *d*1 are equal to 0 ) 0*z* = 1*z* and =

Thus based on the steps the axes are as follows

 Figure Model manipulator diagram with axes based on the modified Denavit-Hatenberg convention

# Step 2 - Denavit-Hartenberg(D-H) parameters

From lecture notes the modified D-H parameters are described as

, , *,* and

Table D-H parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| 1 | 0 | 0 | 0 |  |
| 2 |  |  | 0 |  |
| 3 |  | 0 | 0 |  |
| 4 |  |  |  |  |
| 5 | 0 |  | 0 |  |
| 6 | 0 | 0 |  |  |

# Step 3 - Direct Kinematics Problem

## Joint/link description matrices

From class lecture notes we know that

Joint/link description matrices can be found by putting the DH parameters into the matrix above. Thus the matrices are as follows

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |

## Composition of matrices

To solve the direct kinematics problem form lecture notes we have

Where n is the end-effector frame,

Thus starting with

The output matrix can be written as

, where

# Step 4 - Inverse kinematic problem solution

Given the following parameters solve the inverse kinematic problem

## Solve as a function of given parameters

From

Thus solving for

## Solve as a function of and given parameters

From ,

From ,

Now rearranging the equation

**)**

Introducing the following substitutions

Substituting and squaring both sides the following standard system of equations is obtained:

=

=

Combining the two equations after squaring

Introducing the following substitutions

Thus it will be

From this solving for

**’ or**

## Solve as a function of and given parameters

From ,

From this solving for

**Remember this is solution for to solve for use the equation**

## Solve as a function of and given parameters

From

Thus will be

## Solve as a function of and given parameters

From

Thus will be

Where

## Solve a function of and given parameters

From ,

Thus will be

# Conclusion

In this homework the derivation of the kinematic model of the ABB IRb-7600 manipulator is done, i.e. solving the direct and inverse kinematic problem for that manipulator. During the derivation of the equations MATLAB 2021b has been used to solve the matrix problems.