Ecole Centrale de Nantes
Nantes
EMARO1-ARIA1 Master

Lab N^{o}1: Manipulator modelling

The aim of the lab is to use the symbolic language of MATLAB to establish the geometrical models of manipulator robots.

The first part will be dedicated to the understanding off the provided function **InvTransHom.m** and **DHSym.m**.
The second part will be the use of the two previous functions in order to establish the direct geometrical model of the R3 plan robot. We will :

- describe the different frame to be used
- establish the Modified Denavit-Hartenberg (Khalil Kleinfinger) parameter table
- write a script to compute the direct geometrical model
- provide the equivalent matlab source to be used further in simulation
- compute the inverse dynamic model by writing a script and solving equations system
- provide the equivalent matlab source to be used further in simulation
- siumlate the use of both model

The third part will be to apply the same procedure to a full 6 degrees of freedom cartesian robot.

One written report will be provided by the student developing theory, analysis, discussion and criticism of the results and the modeling techniques.

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1 Analysis of the two functions InvTransHom.m and DHSym.m

Create a personnal directory for the lab1.

From the website, **http://www.irccyn.ec-nantes.fr/~martinet/MoCom.html** download the two functions **InvTransHom.m** and **DHSym.m**.

Analyse and explain their content.

In this aim, you can use the function help under matlab.

2 Modeling of the R3 plan robot

In this section we will consider the robot describe by the following figure:

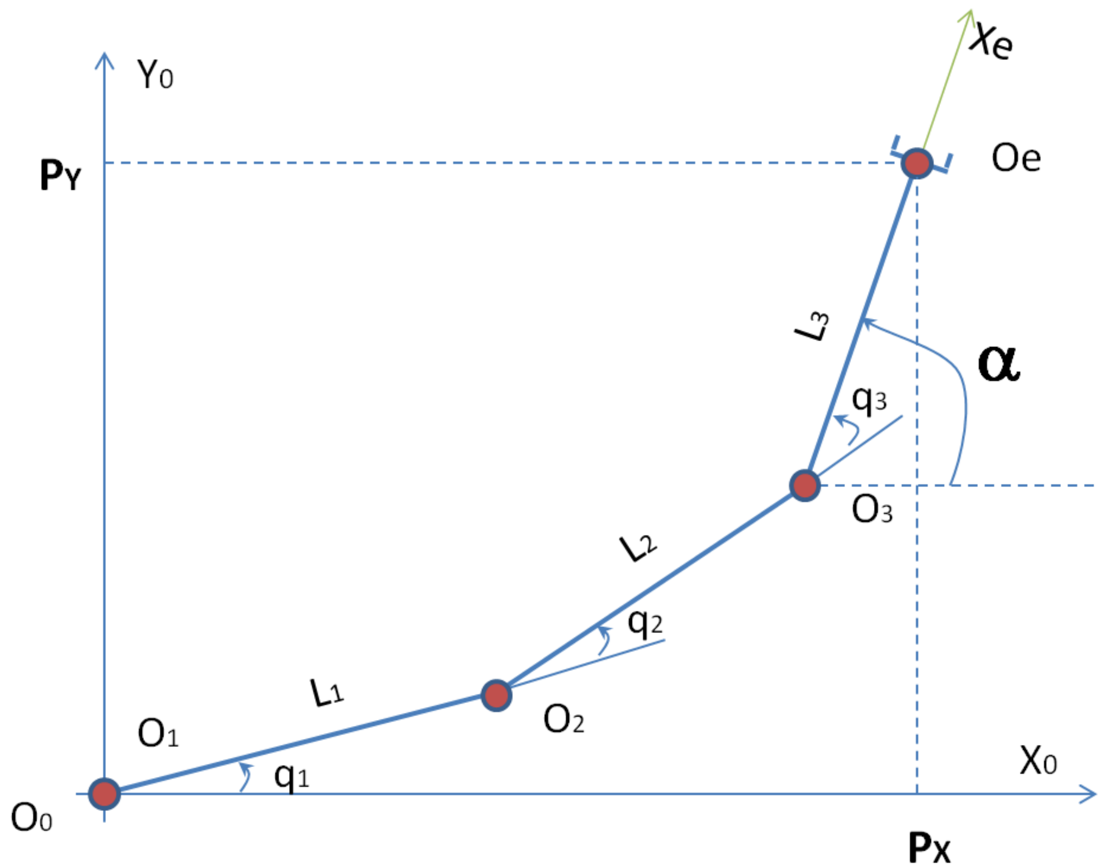


Figure 1: r3plan manipulator robot

From the website, **http://www.irccyn.ec-nantes.fr/~martinet/MoCom.html** download the r3plan.zip file.

2.1 DGM: direct geometrical model

In this subsection, following the modified Denavit Hartenberg convention, you will successively:

- describe all frames to be used (this includes their origins)

- place all z axis
- place all x axis
- establish the Modified Denavit-Hartenberg (Khalil Kleinfinger) parameter table
- write a script **r3plansym.m** to compute the direct geometrical model
- choose $(\mathbf{P_X}, \mathbf{P_Y}, \alpha)$ for the position and orientation of the end effector in the plane
- provide the equivalent matlab source **mgd.m** to be used further in simulation

2.2 IGM: direct geometrical model

For a given $(\mathbf{P_X}, \mathbf{P_Y}, \alpha)$ position and orientation of the end effector in the plane, compute the analytical expression of $\mathbf{q_1}, \mathbf{q_2}, \mathbf{q_3}$). In fact there are two solutions: $(\mathbf{q_{11}}, \mathbf{q_{21}}, \mathbf{q_{31}})$ and $(\mathbf{q_{12}}, \mathbf{q_{22}}, \mathbf{q_{32}})$.

Provide the equivalent matlab source **mgi.m** to be used further in simulation.

2.3 Simulation and visualization of the R3PLAN robot

Use the $menu_{tp}.m$ procedure to simulate, visualize and check your models. Modify the content of **mgdmgi.m** to close the loop.

Check for different configurations. Give results in your report.

3 Modeling of the cartesian robot

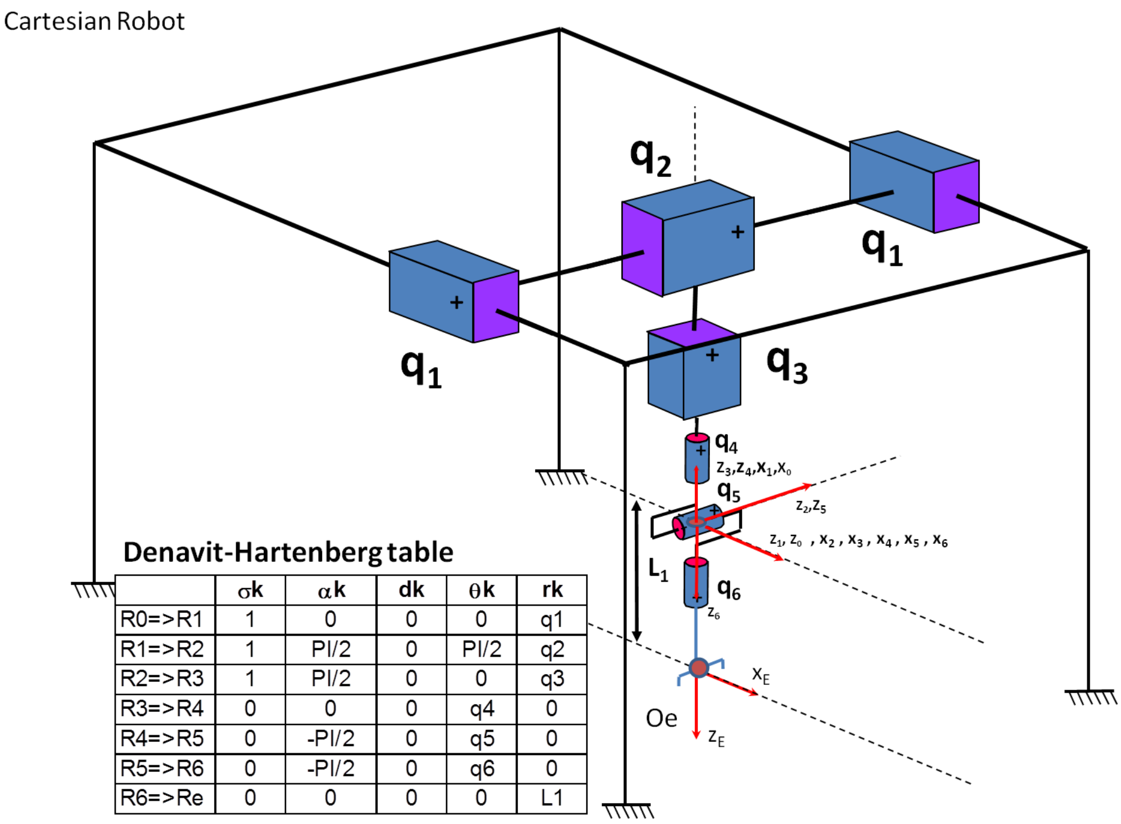
In this section we will consider the cartesian robot describe by the following figure:

From the website, **http://www.irccyn.ec-nantes.fr/-martinet/MoCom.html** download the cartesien.zip file.

3.1 DGM: direct geometrical model

In this subsection, following the modified Denavit Hartenberg convention, you will successively:

- describe all frames to be used (this includes their origins)
- place all z axis
- place all x axis
- establish the Modified Denavit-Hartenberg (Khalil Kleinfinger) parameter table
- write a script **cartesiansym.m** to compute the direct geometrical model
- choose $(\mathbf{P_X}, \mathbf{P_Y}, \mathbf{P_Z}, \theta_\mathbf{x}, \theta_\mathbf{y}, \theta_\mathbf{z})$ for the position and orientation of the end effector in the plane
- provide the equivalent matlab source **mgd.m** to be used further in simulation



	σk	αk	dk	θk	rk
R0=>R1	1	0	0	0	q1
R1=>R2	1	PI/2	0	PI/2	q2
R2=>R3	1	PI/2	0	0	q3
R3=>R4	0	0	0	q4	0
R4=>R5	0	-PI/2	0	q5	0
R5=>R6	0	-PI/2	0	q6	0
R6=>Re	0	0	0	0	L1

Figure 2: cartesian manipulator robot

3.2 IGM: direct geometrical model

For a given $(\mathbf{P_X}, \mathbf{P_Y}, \mathbf{P_Z}, \theta_\mathbf{x}, \theta_\mathbf{y}, \theta_\mathbf{z})$ position and orientation (Bryant angles) of the end effector in the plane, compute the analytical expression of $\mathbf{q_1}, \mathbf{q_2}, \mathbf{q_3}, \mathbf{q_4}, \mathbf{q_5}, \mathbf{q_6}$). In fact there are several solutions.

Provide the equivalent matlab source **mgi.m** to be used further in simulation.

3.3 Simulation and visualization of the Cartesian robot

Download the $menu_{tp}$**.m** procedure to simulate, visualize and check your models. Modify the content of **mgdmgi.m** to close the loop.

Conclude your report on the methodology and on the acquired knowledge.