Robótica I
Grupo 7
2025

Trabajo Práctico N°3

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Grupo: 7

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Ingeniería en Mecatrónica

Ejercicio 1

$$^{0}T_{1} = \mathbf{R}_{z0}(\theta_1)\mathbf{D}_{z0}(d_1)\mathbf{R}_{x1}(\alpha_1)\mathbf{D}_{x1}(a_1)$$

$$\mathbf{R}_z(\theta_i) = \begin{bmatrix} \cos\theta_i & -\sin\theta_i & 0 & 0 \\ \sin\theta_i & \cos\theta_i & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{R}_x(\alpha_i) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha_i & -\sin\alpha_i & 0 \\ 0 & \sin\alpha_i & \cos\alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

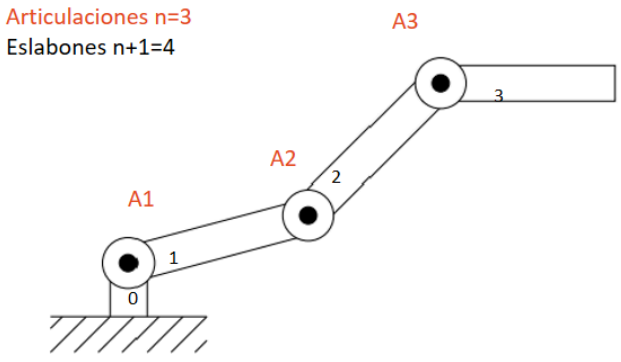
$$\mathbf{D}_x(a_i) = \begin{bmatrix} 1 & 0 & 0 & a_i \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{D}_z(d_i) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

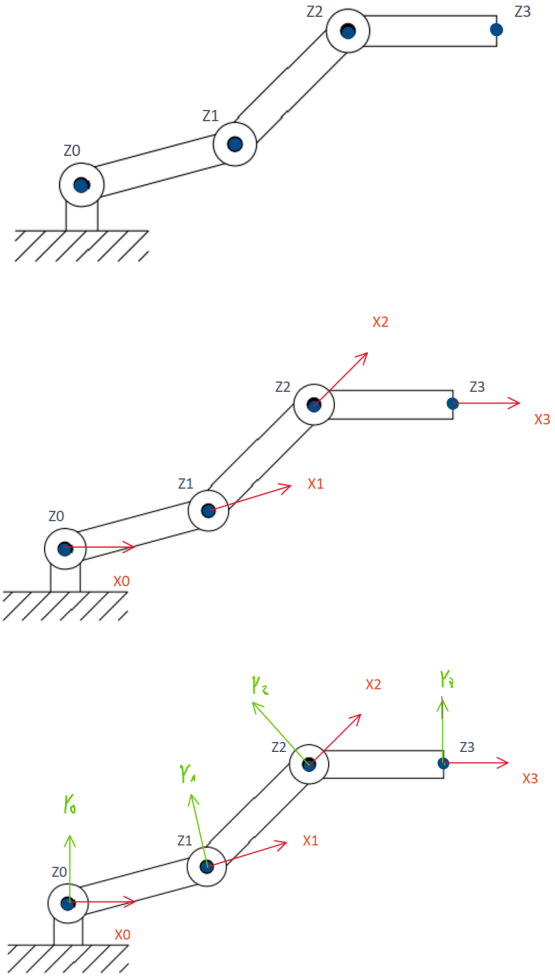
Ejercicio 2

1. Robot planar de 3 articulaciones rotacionales (Spong 2005).

a) Numerar los eslabones de 0 a n
b) Identificar los ejes de cada articulación, en este caso rotacional todos
c) Enumerar los ejes de 1 a n

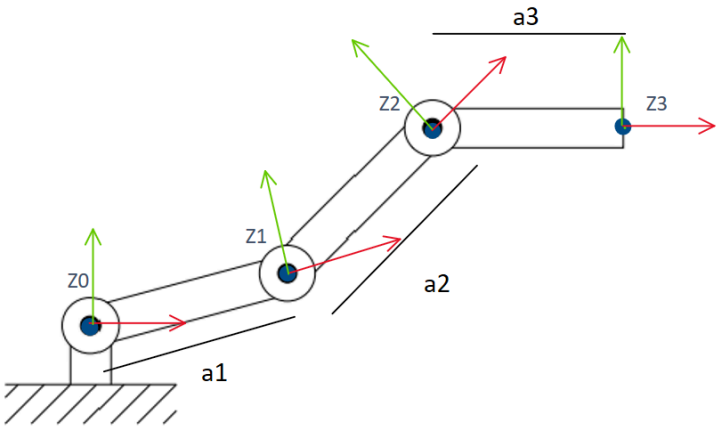


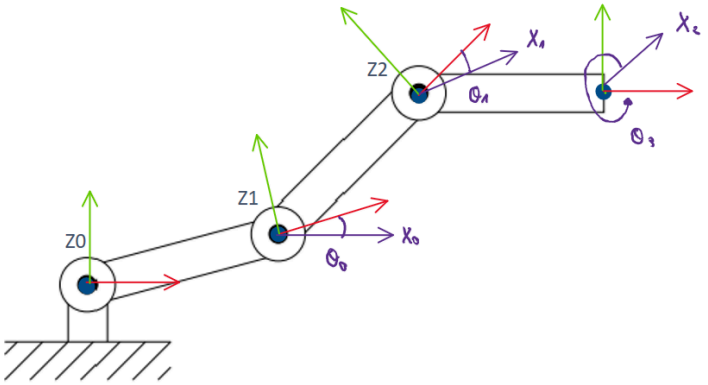
d) Definimos los ejes Z, X e Y de los sistemas 0 a n, comenzando por los del eslabón fijo



Sistemas n+1= 4
Z saliente

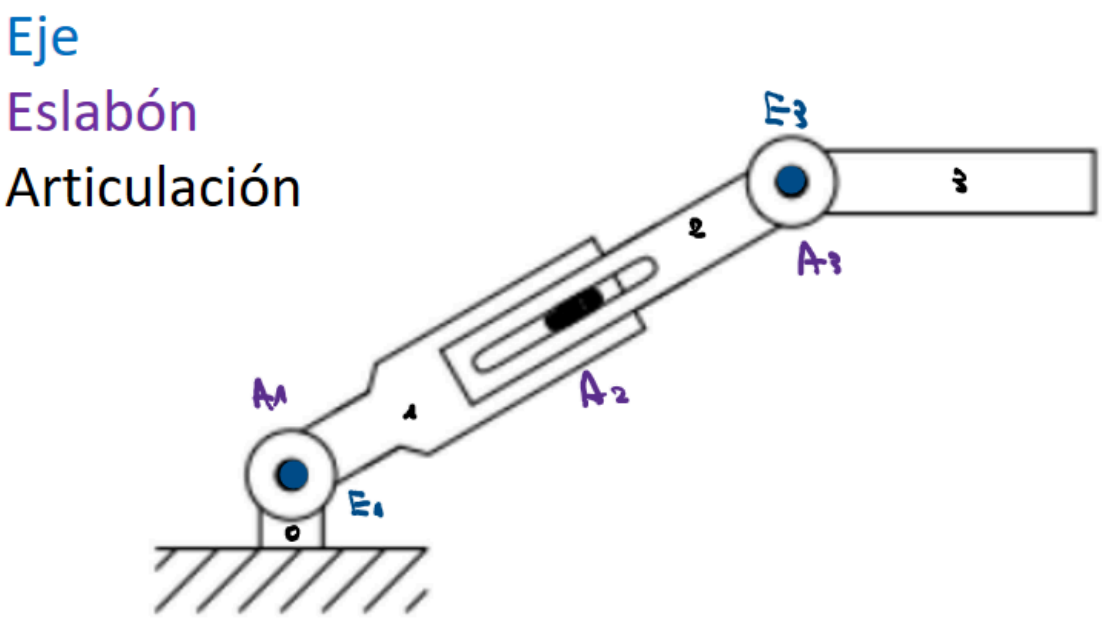
e) Identificacion de parametros

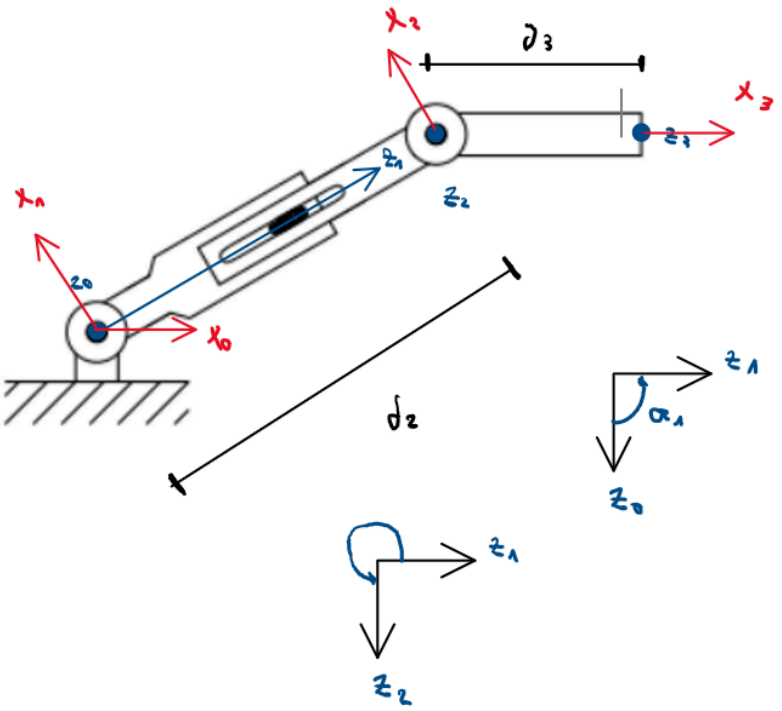




Sistema	θ [rad]	d [mm]	a [mm]	α [rad]	σ
S1	q_1	0	a_1	0	0
S2	q_2	0	a_2	0	0
S3	q_3	0	a_3	0	0

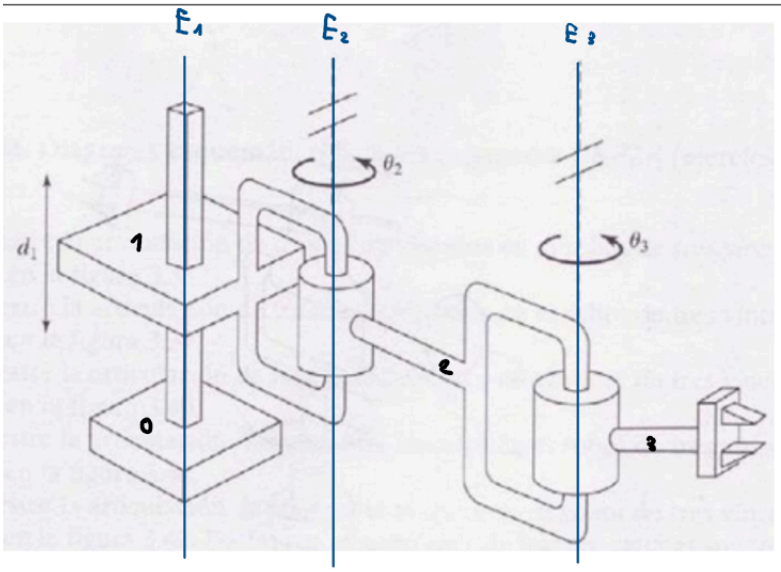
2. Robot planar con 3 articulaciones: rotación, traslación, rotación (Spong 2005).

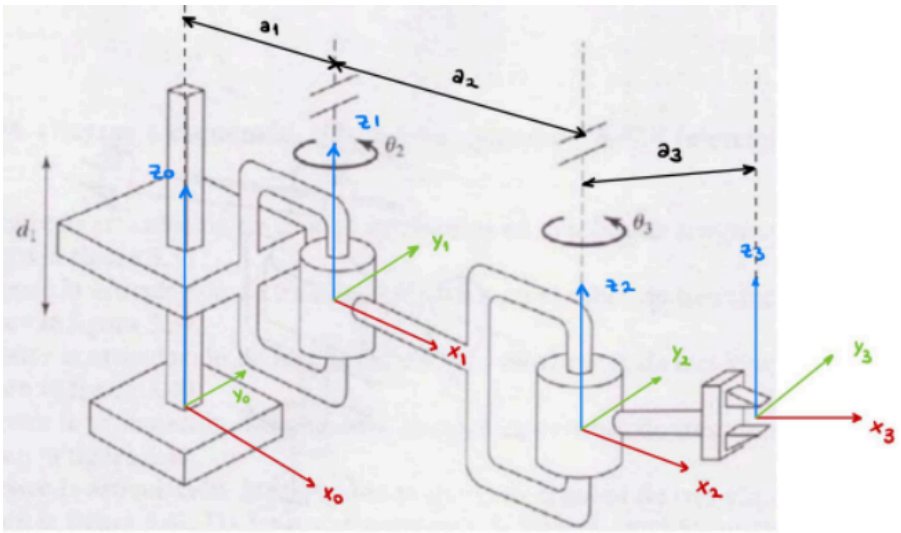




Sistema	θ [rad]	d [mm]	a [mm]	α [rad]	σ
S1	q_1	0	0	$\frac{\pi}{2}$	0
S2	0	d_2	0	$-\frac{\pi}{2}$	1
S3	q_3	0	a_3	0	0

3. Robot de 3 articulaciones: traslación, rotación, rotación (Craig 2006).

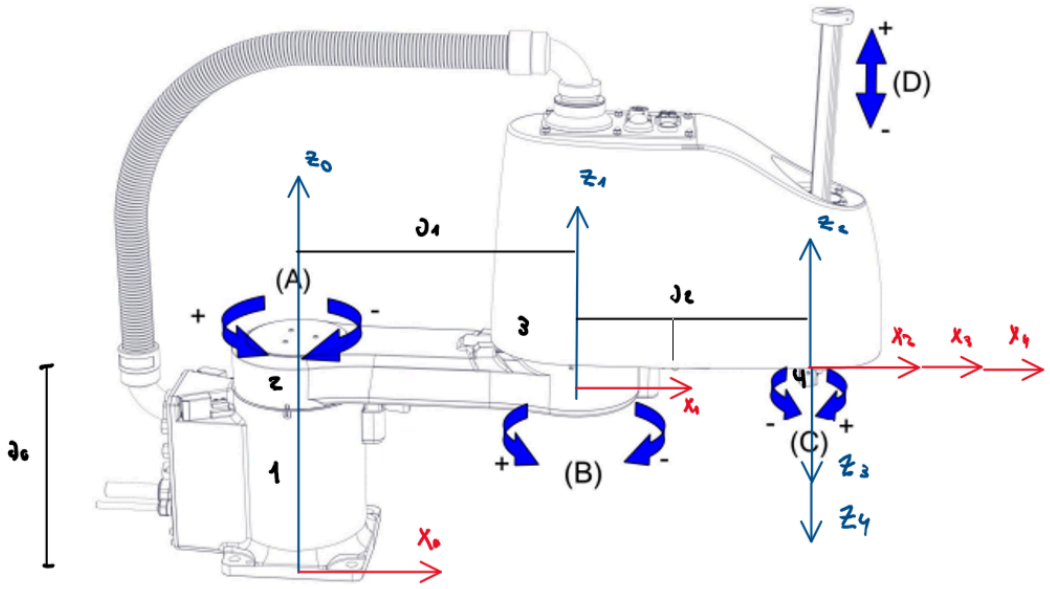




Sistema	θ [rad]	d [mm]	a [mm]	α [rad]	σ
S1	0	d_1	a_1	0	1
S2	q_2	0	a_2	0	0
S3	q_3	0	a_3	0	0

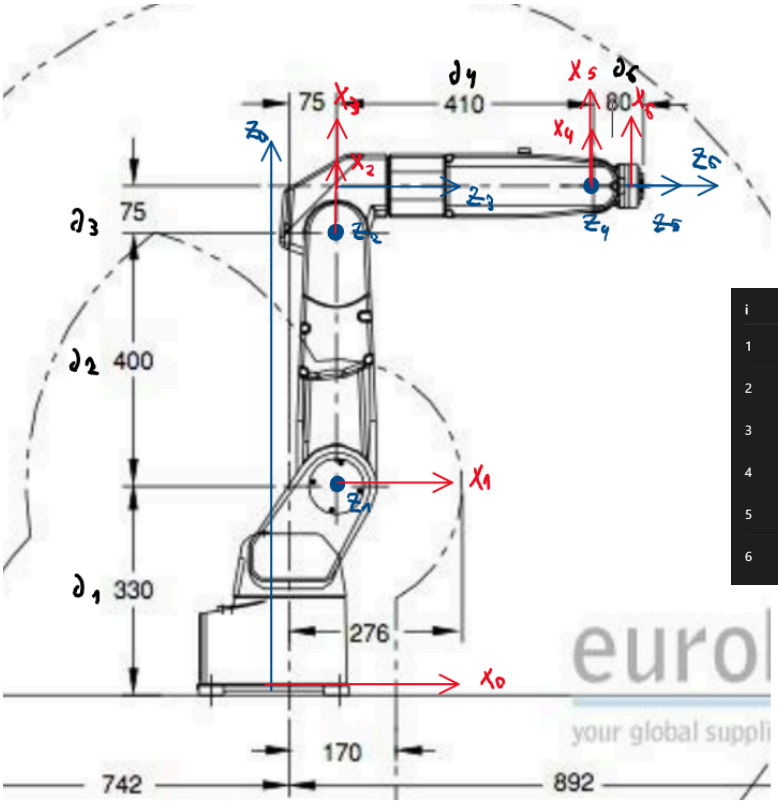
Ejercicio 3

1. SCARA IRB 910SC (ABB).



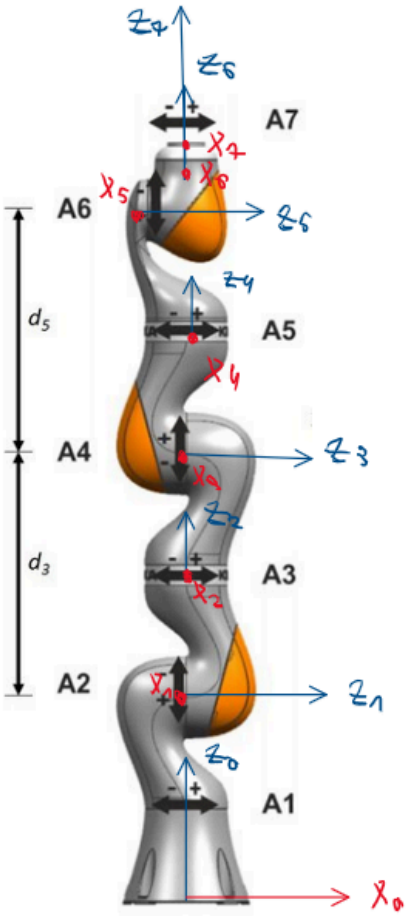
	θ	d	a	α	σ
S_1	φ_1	0,195	0,2	0	0
S_2	φ_2	0	0,25	0	0
S_3	0	0	0	π	1
S_4	φ_4	0	0	0	0

2. Paint Mate 200iA (FANUC).



i	θi	di (m)	ai (m)	αi
1	q1	0.330	0	π/2
2	q2	0	0.400	0
3	q3	0	0.075	π/2
4	q4	0.410	0	-π/2
5	q5	0	0	π/2
6	q6	0.080	0	0

3. LBR iiwa 7 R800 (KUKA).



i	θ_i	d_i	a_i	α_i	Q
1	q_1	d_{14}	0	$-\pi/2$	0
2	q_2	0	0	$\pi/2$	0
3	q_3	d_4	0	$-\pi/2$	0
4	q_4	0	0	$\pi/2$	0
5	q_5	d_4	0	$-\pi/2$	0
6	q_6	0	0	$\pi/2$	0
7	q_7	d_6	0	0	0

Ejercicio 4

Conjunto 1

Sistema	θ	d	a	α	σ
1	q_1	0.262	0.2	π	0
2	q_2	0	0.25	0	0
3	q_3	0	0	0	0
4	π	q_4	0	0	1

Eslabón 1 con α = π

Conjunto 2

Sistema	θ	d	a	α	σ
1	q_1	0.262	0.2	π	0
2	q_2	0	0.25	π	0
3	q_3	0	0	π	0
4	0	q_4	0	0	1

Giro en los ejes de referencia en los sistemas intermedios.

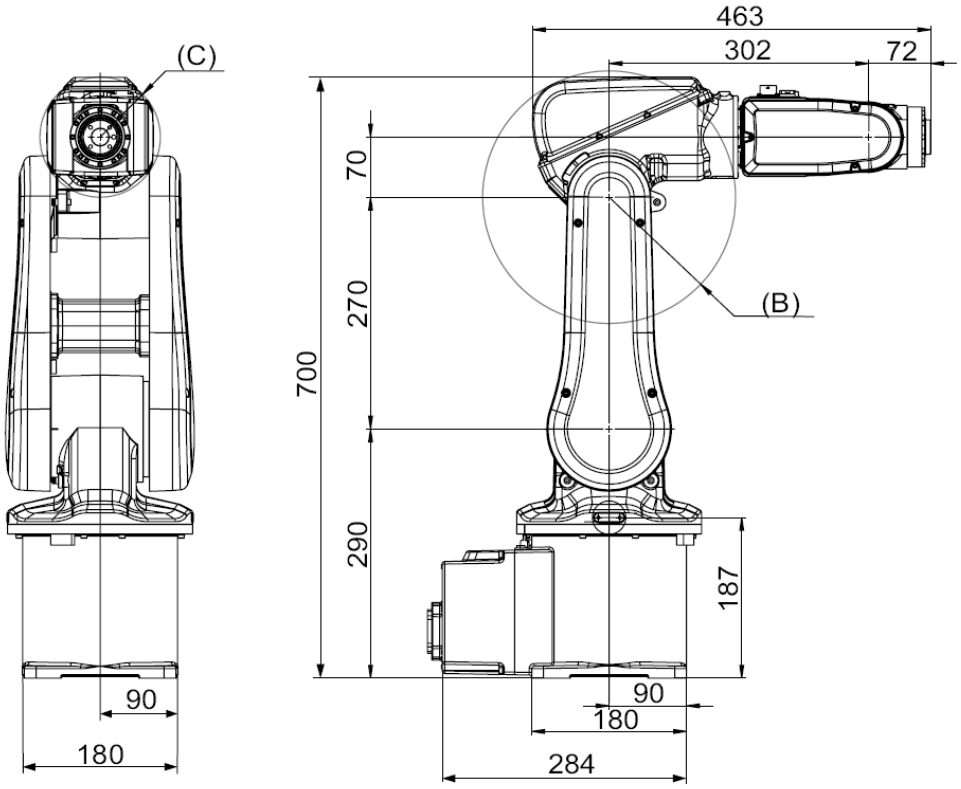
Ejercicio 5

```
%% TP – Ejercicio 5 ( matrices DH)
% Formato DH por fila: [theta  d      a      alpha   sigma]
% sigma = 0 (revoluta), 1 (prismática). Unidades: metros y rad.
close all; clc;
%% ==================== 1) SCARA ABB IRB 910SC (R-R-P-R) ====================
%              th     d       a      al    sg
dh_scara = [    0   0.262   0.20     pi     0;   % eje 1
                0   0       0.25     0      0;   % eje 2
                0   0       0        0      1;   % eje 3 (P)
                0   0       0        0      0];  % eje 4
qlim_scara = [deg2rad([-170 170]);
              deg2rad([-170 170]);
              0 0.20;                    % carrera 0–20 cm
              deg2rad([-360 360])];
SCARA = make_robot_from_dh('ABB\_IRB910SC', dh_scara, qlim_scara);
figure('Name','SCARA ABB IRB 910SC');
SCARA.plot([0 0 0.10 0], 'workspace', [-0.7 0.7 -0.7 0.7 -0.1 0.6], 'scale', 0.8);
SCARA.teach('callback', []);
%% ================ 2) FANUC Paint Mate 200iA (6R compacto) =================
%               th     d       a       al     sg
dh_fanuc = [     0   0.330   0.000    pi/2     0;   % 1
                 0   0.000   0.250    0        0;   % 2
                 0   0.000   0.100   -pi/2     0;   % 3
                 0   0.300   0.000    pi/2     0;   % 4
                 0   0.000   0.000   -pi/2     0;   % 5
                 0   0.080   0.000    0        0];  % 6
qlim_fanuc = [deg2rad([-170 170]);
              deg2rad([-120 120]);
              deg2rad([-155 155]);
              deg2rad([-185 185]);
              deg2rad([-120 120]);
              deg2rad([-360 360])];
PAINTMATE = make_robot_from_dh('FANUC\_PaintMate200iA', dh_fanuc, qlim_fanuc);
figure('Name','FANUC Paint Mate 200iA');
PAINTMATE.plot(zeros(1,6), 'workspace', [-0.8 0.8 -0.8 0.8 -0.1 1.0], 'scale', 0.8);
PAINTMATE.teach('callback', []);
%% ================== 3) KUKA LBR iiwa 7 R800 (7R cobot) ====================
```

```
%               th     d       a       al     sg
dh_iiwa = [      0   0.157   0.000    pi/2     0;  % 1
                 0   0.000   0.200   -pi/2     0;  % 2
                 0   0.000   0.200   -pi/2     0;  % 3
                 0   0.000   0.080    pi/2     0;  % 4
                 0   0.000   0.120    pi/2     0;  % 5
                 0   0.000   0.040   -pi/2     0;  % 6
                 0   0.126   0.000    0        0]; % 7
qlim_iiwa = [deg2rad([-170 170]);
             deg2rad([-120 120]);
             deg2rad([-170 170]);
             deg2rad([-120 120]);
             deg2rad([-170 170]);
             deg2rad([-120 120]);
             deg2rad([-360 360])];
IIWA = make_robot_from_dh('KUKA\_LBR\_iiwa7\_R800', dh_iiwa, qlim_iiwa);
figure('Name','KUKA LBR iiwa 7 R800');
IIWA.plot(zeros(1,7), 'workspace', [-0.9 0.9 -0.9 0.9 -0.2 1.2], 'scale', 0.8);
IIWA.teach('callback', []);
%% ========================= Función auxiliar ==========================
(Sugerida por la IA)
% Construye un SerialLink desde una matriz DH estándar.
% dh: Nx5  [theta d a alpha sigma]; qlims opcional Nx2 en rad o m.
function R = make_robot_from_dh(name, dh, qlims)
   L(1:size(dh,1)) = Link; % prealocar
   for i = 1:size(dh,1)
       L(i) = Link(dh(i,:), 'standard');   % DH estándar
       if nargin >= 3 && ~isempty(qlims)
           L(i).qlim = qlims(i,:);
       end
   end
   R = SerialLink(L, 'name', name);
end
```

Ejercicio TF

Por el momento, los scripts se realizaron en base a las medidas del robot *ABB IRB 120.*



robot.m

```
%Trabajo practico N° 3: definición del robot
clc, clear, close all
%definimos matriz DH
% dh = [tita d a alfa sigma]
dh = [ 0    0.290   0      -pi/2   0;
       0    0       0.270   0      0;
       0    0       0.070  -pi/2   0;
       0    0.302   0       pi/2   0;
       0    0       0      -pi/2   0;
       0    0.072   0       0      0 ];
R1 = SerialLink(dh,'name','ABB IRB120 SC #1');
```

```
R2 = SerialLink(dh, 'name', 'ABB IRB120 SC #2');
R1.qlim = deg2rad([ -165  165;
                    -110  110;
                    -110  70;
                    -160  160;
                    -120  120;
                    -400  400 ]);
R2.qlim = R1.qlim;
R1.offset = [0, -pi/2, 0, 0, 0, 0];
R2.offset = R1.offset;
robots = {R1, R2};
limx = 1.3;
limy = 1.3;
limz = 1.3;
workspace = [-limx limx -limy limy 0 limz];
```

invKine_utility.m

```
clc, clear, close all
if exist('robot.m', 'file') == 2
   run('robot.m');
end
%% === Verificación de robots ===
assert(isa(R1,'SerialLink'), 'R1 debe ser un objeto SerialLink
(RTB de Corke).');
assert(isa(R2,'SerialLink'), 'R2 debe ser un objeto SerialLink
(RTB de Corke).');
assert(R1.mdh == 0, 'Se espera DH estándar (R1.mdh == 0).');
%% === Configuración articular de ejemplo ===
q1 = [pi/2, -pi/4, 0, pi/3, pi, 0];
q2 = q1;   % idéntico al primero (puedes cambiarlo luego)
R1.base = transl(0.5,0,0)*trotz(pi/4);
R2.base = transl(-0.5,0,0)*trotz(-pi/4);
R1.tool = trotz(pi/3);
% sistemas1 = true(1, R1.n + 1);
% sistemas2 = true(1, R2.n + 1);
sistemas1 = [1, 0, 0, 0, 0, 0,0];
```

```
sistemas2 = [1, 0, 0, 0, 0, 0,0];
%% === Calcular marcos DH R1 ===
Tlist1 = cell(R1.n+1,1);
T = R1.base; Tlist1{1} = T;
for i = 1:R1.n
   Ai = R1.links(i).A(q1(i));
   T = T * Ai;
   Tlist1{i+1} = T;
end
%% === Calcular marcos DH R2 ===
Tlist2 = cell(R2.n+1,1);
T = R2.base; Tlist2{1} = T;
for i = 1:R2.n
   Ai = R2.links(i).A(q2(i));
   T = T * Ai;
   Tlist2{i+1} = T;
end
%% === Graficar robots en la misma figura ===
figure('Color','w');
axis(workspace);
axis equal
%% === Graficar marcos DH ===
Laxis = 0.2 * workspace(2);
for i = 0:R1.n
   if sistemas1(i+1)
       trplot(Tlist1{i+1}, 'frame', sprintf('{%d}_1',i), ...
              'length',Laxis,'rgb','arrow','width',0.5, ...
              'text_opts',{'FontSize',14});
   end
end
for i = 0:R2.n
   if sistemas2(i+1)
       trplot(Tlist2{i+1}, 'frame', sprintf('{%d}_2',i), ...
              'length',Laxis,'rgb','arrow','width',0.5, ...
              'text_opts',{'FontSize',14});
   end
end
R1.plot(q1, 'workspace', workspace, 'scale',0.8, 'jointdiam',1.4,
'notiles');hold on;
R2.plot(q2, 'workspace', workspace, 'scale',0.8, 'jointdiam',1.4,
'notiles');hold off;
xlabel('X'); ylabel('Y'); zlabel('Z');
```

```
title('Robots colaborativos');
grid on;
R2.teach(q2);
```