Robotica Taller 2

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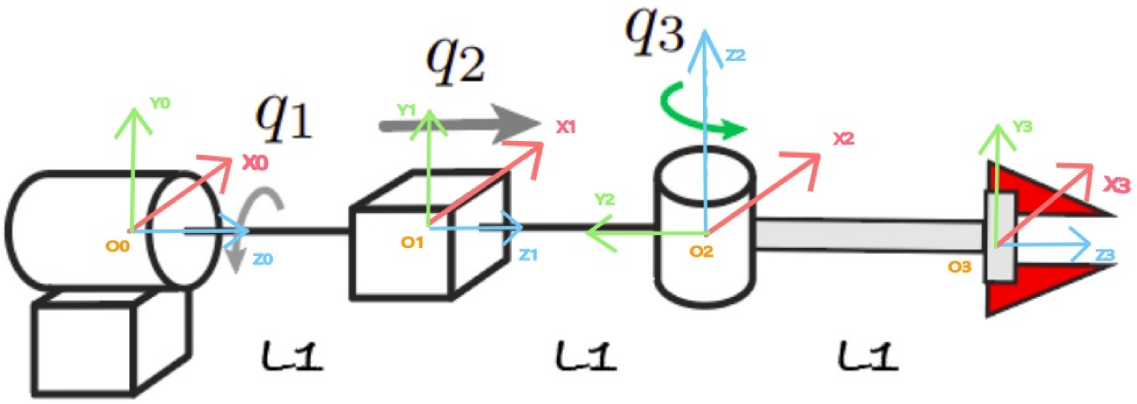
1

```
imshow("punto_1.jpg")
```



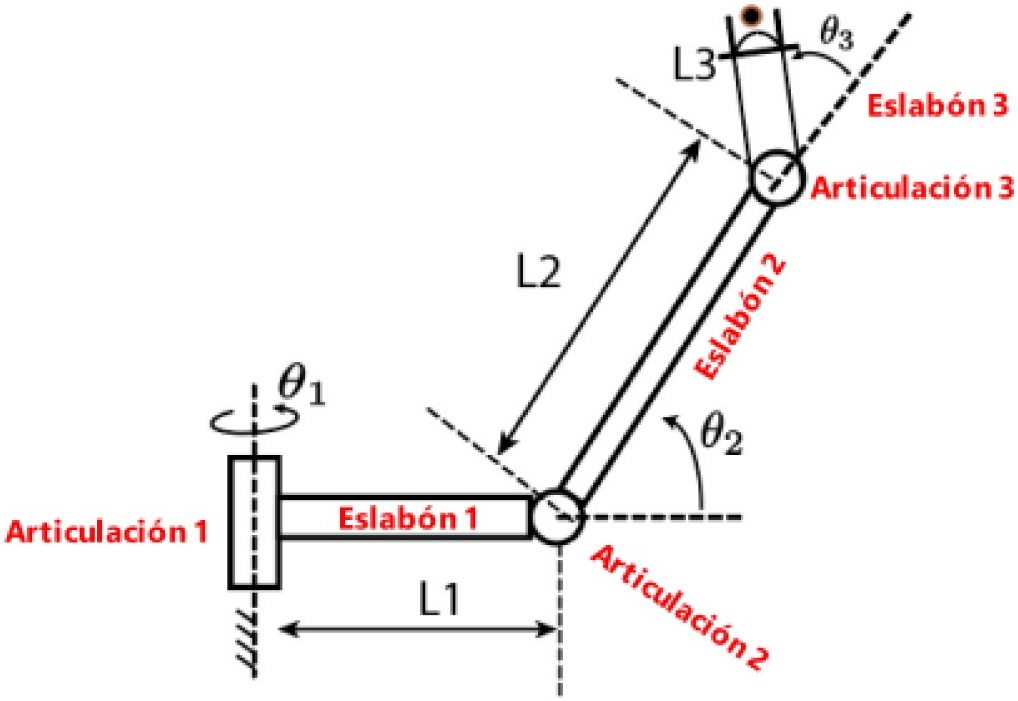

```
syms L1;
a = {0; 0; 0};
alpha = {0; 0; 90};
d = {0; L1; L1};
theta = {0; 0; 0};
table(a, alpha, d, theta)
```

ans = 3×4 table

	a	alpha	d	theta
1	0	0	0	0
2	0	0	L1	0
3	0	90	L1	0

2

```
imshow("punto_2_a.jpg");
```




```
imshow("punto_2_b.jpg");

syms L1 L2 L3 theta_1 theta_2 theta_3;
a = {0; L1; L2; L3};
alpha = {0; 90; 0; 0};
d = {0; 0; 0; 0};
theta = {0; theta_1; theta_2; theta_3};
tabla_2 = table(a, alpha, d, theta)
```

tabla_2 = 4×4 table

	a	alpha	d	theta
1	0	0	0	0
2	L1	90	0	theta_1
3	L2	0	0	theta_2
4	L3	0	0	theta_3

```
t10 = mth_dh(L1, 90, 0, 0)
```

t10 =

$$\begin{pmatrix} 1 & 0 & 0 & L_1 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t21 = mth_dh(L2, 0, 0, theta_2)
```

t21 =

$$\begin{pmatrix} \cos\left(\frac{\pi\,\theta_2}{180}\right) & -\sin\left(\frac{\pi\,\theta_2}{180}\right) & 0 & L_2\cos\left(\frac{\pi\,\theta_2}{180}\right) \\ \sin\left(\frac{\pi\,\theta_2}{180}\right) & \cos\left(\frac{\pi\,\theta_2}{180}\right) & 0 & L_2\sin\left(\frac{\pi\,\theta_2}{180}\right) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t32 = mth_dh(L3, 0, 0, theta_3)
```

t32 =

$$\begin{pmatrix} \cos\left(\frac{\pi\,\theta_3}{180}\right) & -\sin\left(\frac{\pi\,\theta_3}{180}\right) & 0 & L_3\cos\left(\frac{\pi\,\theta_3}{180}\right) \\ \sin\left(\frac{\pi\,\theta_3}{180}\right) & \cos\left(\frac{\pi\,\theta_3}{180}\right) & 0 & L_3\sin\left(\frac{\pi\,\theta_3}{180}\right) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t30 = t10*t21*t32
```

t30 =

$$\begin{pmatrix} \sigma_1 & -\sigma_3\,\sigma_4 - \sigma_5\,\sigma_2 & 0 & L_1 + L_2\,\sigma_3 + L_3\,\sigma_3\,\sigma_5 - L_3\,\sigma_2\,\sigma_4 \\ 0 & 0 & -1 & 0 \\ \sigma_3\,\sigma_4 + \sigma_5\,\sigma_2 & \sigma_1 & 0 & L_2\,\sigma_2 + L_3\,\sigma_3\,\sigma_4 + L_3\,\sigma_5\,\sigma_2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

where

$$\sigma_1 = \sigma_3\,\sigma_5 - \sigma_2\,\sigma_4$$

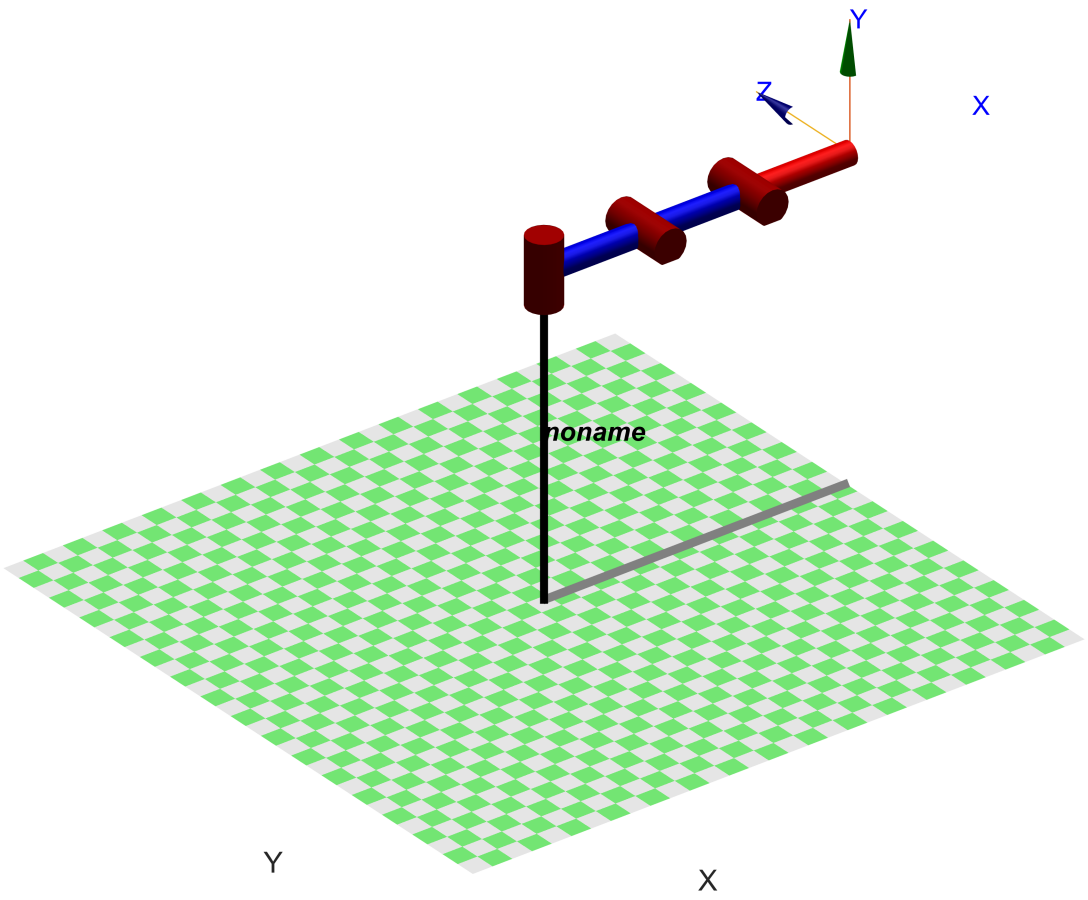
$$\sigma_2 = \sin\left(\frac{\pi\,\theta_2}{180}\right)$$

$$\sigma_3 = \cos\left(\frac{\pi\,\theta_2}{180}\right)$$

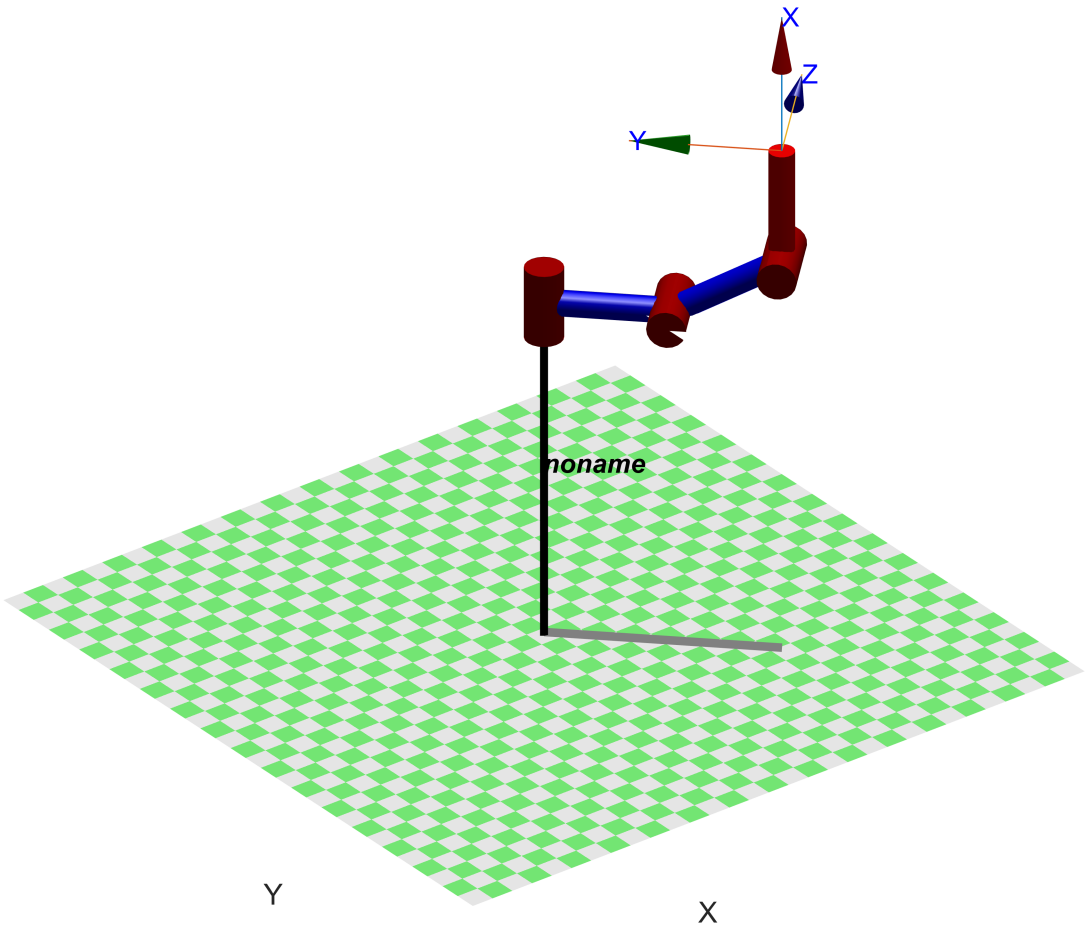
$$\sigma_4 = \sin\left(\frac{\pi\,\theta_3}{180}\right)$$

$$\sigma_5 = \cos\left(\frac{\pi\,\theta_3}{180}\right)$$

```
Theta_1=0;
Theta_2=0;
Theta_3=0;



L1 = Link('revolute','a',1,'alpha',pi/2,'d',0,'offset',Theta_1);
L2 = Link('revolute','a',1,'alpha',0,'d',0,'offset',Theta_2);
L3 = Link('revolute','a',1,'alpha',0,'d',0,'offset',Theta_2);

Robot = SerialLink([L1 L2 L3]);


q_z = [0 0 0];
q_1 = [pi/4 pi/6 pi/3];

Robot.plot(q_z)
```




```
Robot.plot(q_1)
```



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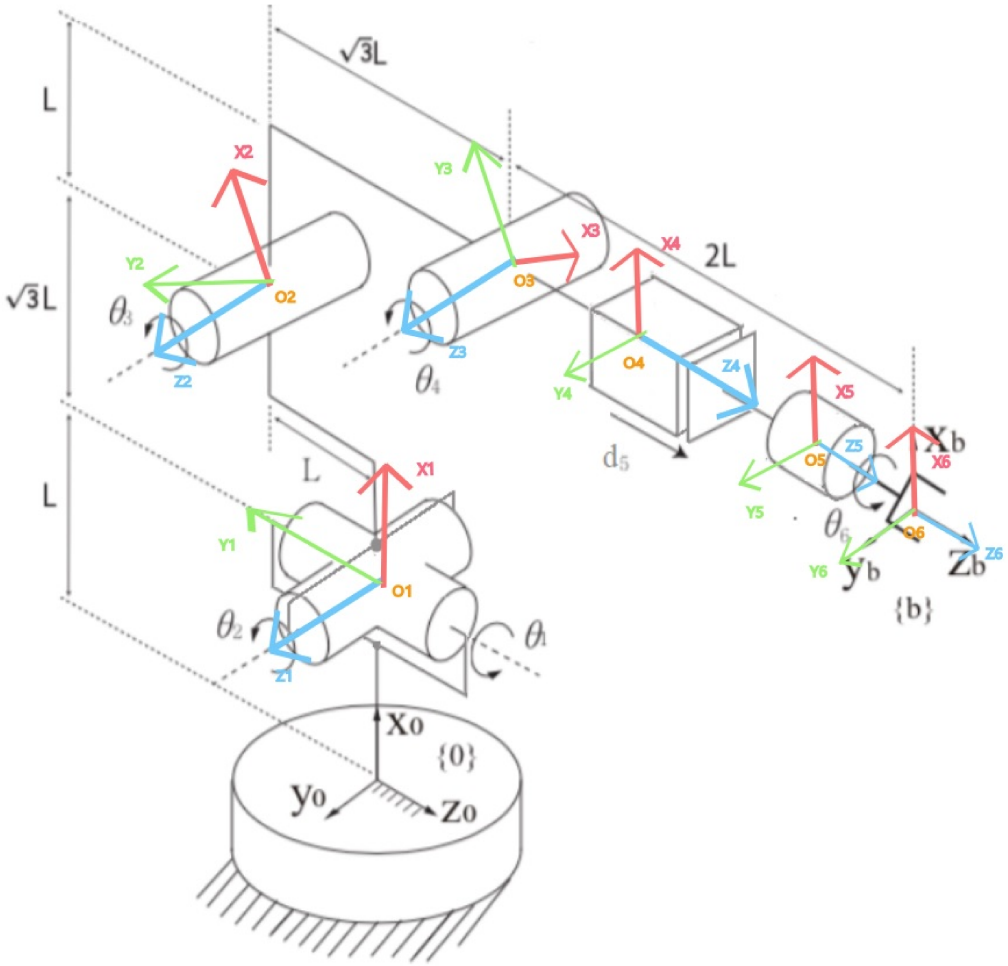
```
imshow("punto_3.jpg")
```




```
syms L theta_1 theta_2 theta_3 theta_4  ds theta_6;
a = {L; sqrt(L^2 + (sqrt(3)*L)^2); sqrt(L^2 + (sqrt(3)*L)^2); 0; 0; 0};
alpha = {-90; 0; 0; 90; 0; 0};
d = {0; 0; 0; 2*L; ds; 0};
theta = {theta_1; theta_2; theta_3; theta_4; 0; theta_6};
tabla_3 = table(a, alpha, d, theta)
```

tabla_3 = 6×4 table

	a	alpha	d	theta
1	L	-90	0	theta_1
2	2*(L^2)^(...	0	0	theta_2

	a	alpha	d	theta
3	2*(L^2)^(...	0	0	theta_3
4	0	90	2*L	theta_4
5	0	0	ds	0
6	0	0	0	theta_6

```
t10 = mth_dh(L, -90, 0, theta_1)
```

t10 =

$$\begin{pmatrix} \cos\left(\frac{\pi\,\theta_1}{180}\right) & 0 & -\sin\left(\frac{\pi\,\theta_1}{180}\right) & L\cos\left(\frac{\pi\,\theta_1}{180}\right) \\ \sin\left(\frac{\pi\,\theta_1}{180}\right) & 0 & \cos\left(\frac{\pi\,\theta_1}{180}\right) & L\sin\left(\frac{\pi\,\theta_1}{180}\right) \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t21 = mth_dh(sqrt(L^2 + (sqrt(3)*L)^2), 0, 0, theta_2)
```

t21 =

$$\begin{pmatrix} \cos\left(\frac{\pi\,\theta_2}{180}\right) & -\sin\left(\frac{\pi\,\theta_2}{180}\right) & 0 & 2\cos\left(\frac{\pi\,\theta_2}{180}\right)\sqrt{L^2} \\ \sin\left(\frac{\pi\,\theta_2}{180}\right) & \cos\left(\frac{\pi\,\theta_2}{180}\right) & 0 & 2\sin\left(\frac{\pi\,\theta_2}{180}\right)\sqrt{L^2} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t32 = mth_dh(sqrt(L^2 + (sqrt(3)*L)^2), 0, 0, -theta_3)
```

t32 =

$$\begin{pmatrix} \cos\left(\frac{\pi\,\theta_3}{180}\right) & \sin\left(\frac{\pi\,\theta_3}{180}\right) & 0 & 2\cos\left(\frac{\pi\,\theta_3}{180}\right)\sqrt{L^2} \\ -\sin\left(\frac{\pi\,\theta_3}{180}\right) & \cos\left(\frac{\pi\,\theta_3}{180}\right) & 0 & -2\sin\left(\frac{\pi\,\theta_3}{180}\right)\sqrt{L^2} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t43 = mth_dh(0, 90, 2*L, theta_4)
```

t43 =

$$\begin{pmatrix} \cos\left(\frac{\pi\,\theta_4}{180}\right) & 0 & \sin\left(\frac{\pi\,\theta_4}{180}\right) & 0 \\ \sin\left(\frac{\pi\,\theta_4}{180}\right) & 0 & -\cos\left(\frac{\pi\,\theta_4}{180}\right) & 0 \\ 0 & 1 & 0 & 2\,L \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t54 = mth_dh(0, 0, ds, 0)
```

t54 =

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & \mathrm{ds} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t65 = mth_dh(0, 0, 0, theta_6)
```

t65 =

$$\begin{pmatrix} \cos\left(\frac{\pi\,\theta_6}{180}\right) & -\sin\left(\frac{\pi\,\theta_6}{180}\right) & 0 & 0 \\ \sin\left(\frac{\pi\,\theta_6}{180}\right) & \cos\left(\frac{\pi\,\theta_6}{180}\right) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

MTH TCP

```
syms l_tool
t_tcp = mth_dh(0, 0, l_tool, 0)
```

t_tcp =

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & l_{\mathrm{tool}} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Modelo geométrico directo

```
t10 = mth_dh(L, -90, 0, 0);
t21 = mth_dh(sqrt(L^2 + (sqrt(3)*L)^2), 0, 0, 0);
t32 = mth_dh(sqrt(L^2 + (sqrt(3)*L)^2), 0, 0, 0);
t43 = mth_dh(0, 90, 2*L, 0);
t54 = mth_dh(0, 0, 0, 0);
t65 = mth_dh(0, 0, 0, 0);
t_mgd = t10*t21*t32*t43*t54*t65
```

t_mgd =

$$\begin{pmatrix} 1 & 0 & 0 & L+4\sqrt{L^2} \\ 0 & 1 & 0 & 2L \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

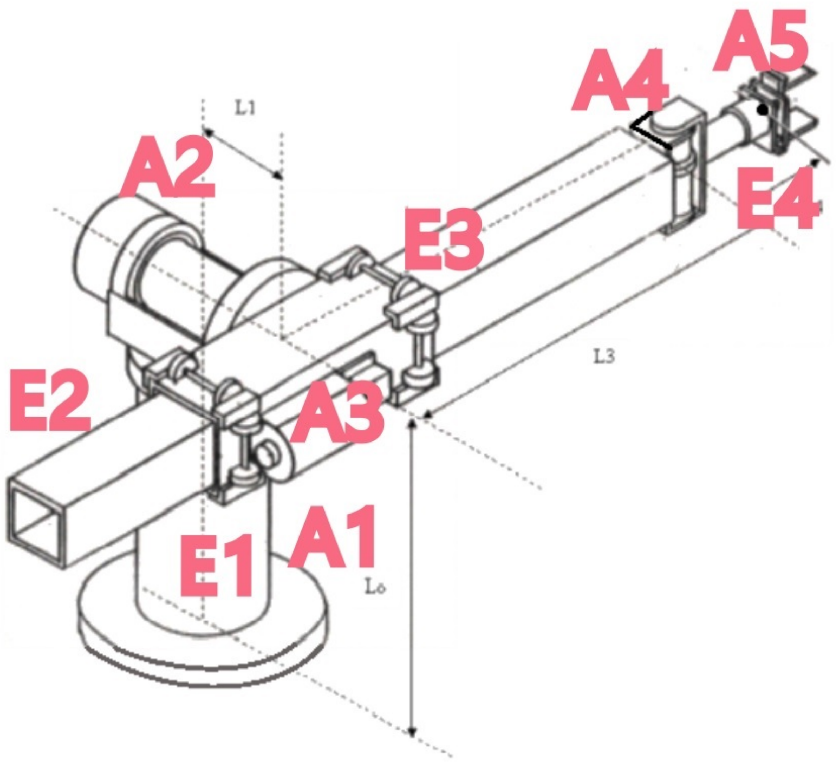
Posición y orientación con configuración dada

```
t10 = mth_dh(1, -90, 0, 60);
t21 = mth_dh(sqrt(1^2 + (sqrt(3)*1)^2), 0, 0, -45);
t32 = mth_dh(sqrt(1^2 + (sqrt(3)*1)^2), 0, 0, -90);
t43 = mth_dh(0, 90, 2*1, 45);
t54 = mth_dh(0, 0, 1.5, 0);
t65 = mth_dh(0, 0, 0, 30);
t_mgd_conf = t10*t21*t32*t43*t54*t65
```

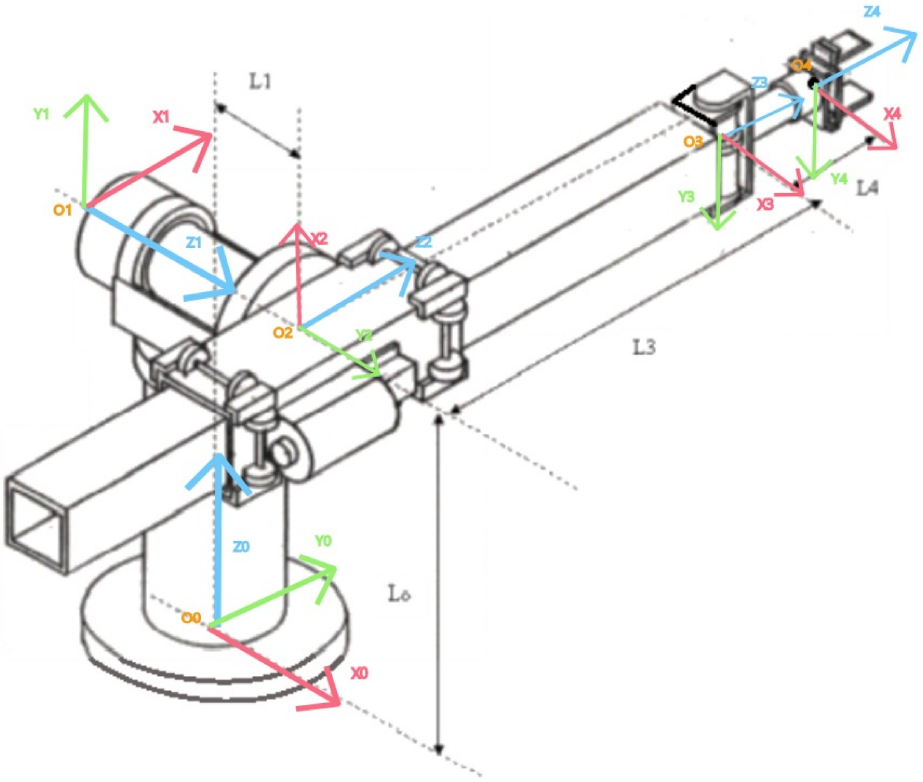
```
t_mgd_conf = 4×4
   -0.4330   -0.7500   -0.5000   -1.9821
    0.2500    0.4330   -0.8660    0.5670
    0.8660   -0.5000         0    2.8284
         0         0         0    1.0000
```

4

```
imshow("punto_4_a.jpg")
```




```
imshow("punto_4_b.jpg")
```




```
syms L0 L1 L3 L4;
a = {0; L1; 0; 0; 0};
alpha = {0; 90; 90; 0; 0};
d = {0; L0; 0; L3; L4};
theta = {0; 90; 90; 90; 0};
tabla_4 = table(a, alpha, d, theta)
```

tabla_4 = 5×4 table

	a	alpha	d	theta
1	0	0	0	0
2	L1	90	L0	90

	a	alpha	d	theta
3	0	90	0	90
4	0	0	L3	90
5	0	0	L4	0

```
t10 = mth_dh(L1, 90, L0, 90)
```

t10 =

$$\begin{pmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & L_1 \\ 0 & 1 & 0 & L_0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t21 = mth_dh(0, 90, 0, 90)
```

t21 = 4×4

0	0	1	0
1	0	0	0
0	1	0	0
0	0	0	1

```
t32 = mth_dh(0, 0, L3, 90)
```

t32 =

$$\begin{pmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & L_3 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t43 = mth_dh(0, 0, L4, 0)
```

t43 =

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & L_4 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

```
t_modelo_geometrico = t10*t21*t32*t43
```

t_modelo_geometrico =

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & L_1 + L_3 + L_4 \\ 0 & -1 & 0 & L_0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Configuración dada

```
t10 = mth_dh(0.5, 90, 3, 90);
```

```
t21 = mth_dh(0, 90, 0, 90);
t32 = mth_dh(0, 0, 1, 90);
t43 = mth_dh(0, 0, 0.5, 0);
t_modelo_geometrico = t10*t21*t32*t43
```

```
t_modelo_geometrico = 4×4
     1     0     0     0
     0     0     1     2
     0    -1     0     3
     0     0     0     1
```

5

```
imshow("punto_5.jpg")
```

```
syms q1 q2 q3 q4 q5 q6;
a = [0 0 1 0 0 0 0]';
alpha = [0 pi/2 0 pi/2 pi/4 3*pi/4 0]';
d = [1 1 0 0 0 sqrt(1.25) 1]';
theta = [0 0 0 0 pi/2 0 0]';
offset = [0 pi/2 0 pi/2 0 pi 0]';
rob = [a,alpha,d,theta,offset]
```

```
rob = 7×5
         0         0    1.0000         0         0
         0    1.5708    1.0000         0    1.5708
    1.0000         0         0         0         0
```

```
         0    1.5708         0         0    1.5708
         0    0.7854         0    1.5708         0
         0    2.3562    1.1180         0    3.1416
         0         0    1.0000         0         0
```

```
table(rob)
```

ans = 7×1 table

...

	rob			
1	0	0	1	0
2	0	1.5708	1	0
3	1	0	0	0
4	0	1.5708	0	0
5	0	0.7854	0	1.5708
6	0	2.3562	1.1180	0
7	0	0	1	0

Funciones de ayuda

```
function [MTHtx] = mth_trans_x(dist)
    MTHtx = [1 0 0 dist; 0 1 0 0; 0 0 1 0; 0 0 0 1];
end

function [MTHty] = mth_trans_y(dist)
    MTHty = [1 0 0 0; 0 1 0 dist; 0 0 1 0; 0 0 0 1];
end

function [MTHtz] = mth_trans_z(dist)
    MTHtz = [1 0 0 0; 0 1 0 0; 0 0 1 dist; 0 0 0 1];
end

function [MTHrx] = mth_rot_x(ang)
    MTHrx = [1 0 0 0; 0 cosd(ang) -sind(ang) 0; 0 sind(ang) cosd(ang) 0; 0 0 0 1];
end

function [MTHry] = mth_rot_y(ang)
    MTHry = [cosd(ang) 0 sind(ang) 0; 0 1 0 0; -sind(ang) 0 cosd(ang) 0; 0 0 0 1];
end

function [MTHrz] = mth_rot_z(ang)
    MTHrz = [cosd(ang) -sind(ang) 0 0; sind(ang) cosd(ang) 0 0; 0 0 1 0; 0 0 0 1];
end

function [MTHt] = mth_trans(x,y,z)
    MTHt = mth_trans_x(x) * mth_trans_y(y) * mth_trans_z(z);
end
```

```
function [MTHr] = mth_rot(x,y,z)
    MTHr = mth_rot_x(x) * mth_rot_y(y) * mth_rot_z(z);
end

function [MTH] = mth(x,y,z, angx, angy, angz)
    MTH = mth_trans(x,y,z) * mth_rot(angx,angy,angz);
end

function [MTH_inv] = mth_inv(mth)
    R = mth(1:3, 1:3);
    d = mth(1:3, 4);
    MTH_inv = [R' -R'*d; 0 0 0 1];
end

function [MTH_DH] = mth_dh(a_i, alpha_i, d_i, theta_i)
    MTH_DH = mth_rot_z(theta_i) * mth_trans_z(d_i) * mth_trans_x(a_i) * mth_rot_x(alpha_i);
end
```