CINEMATICA

MATLAB

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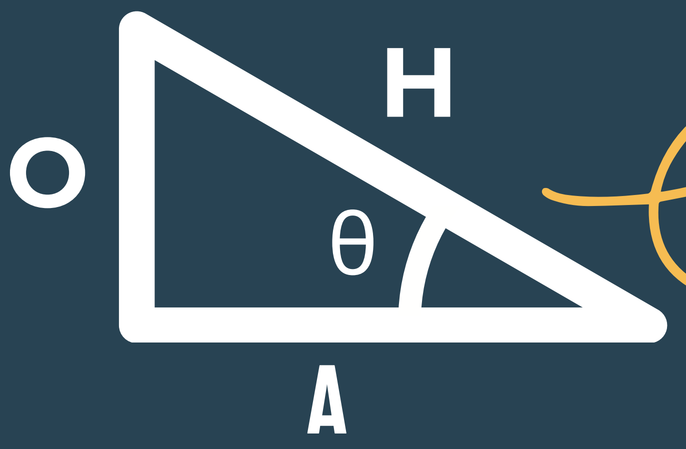

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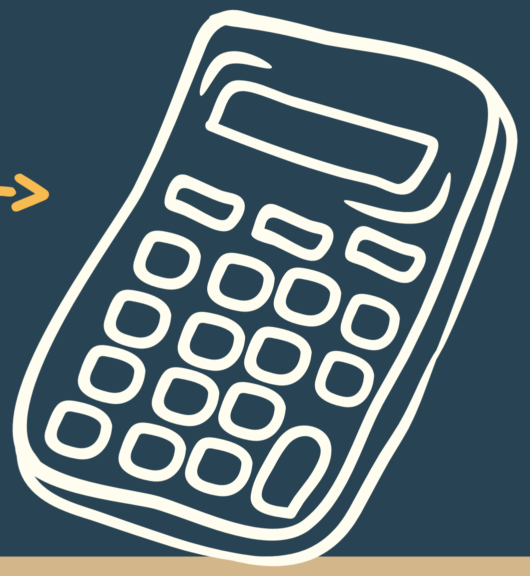
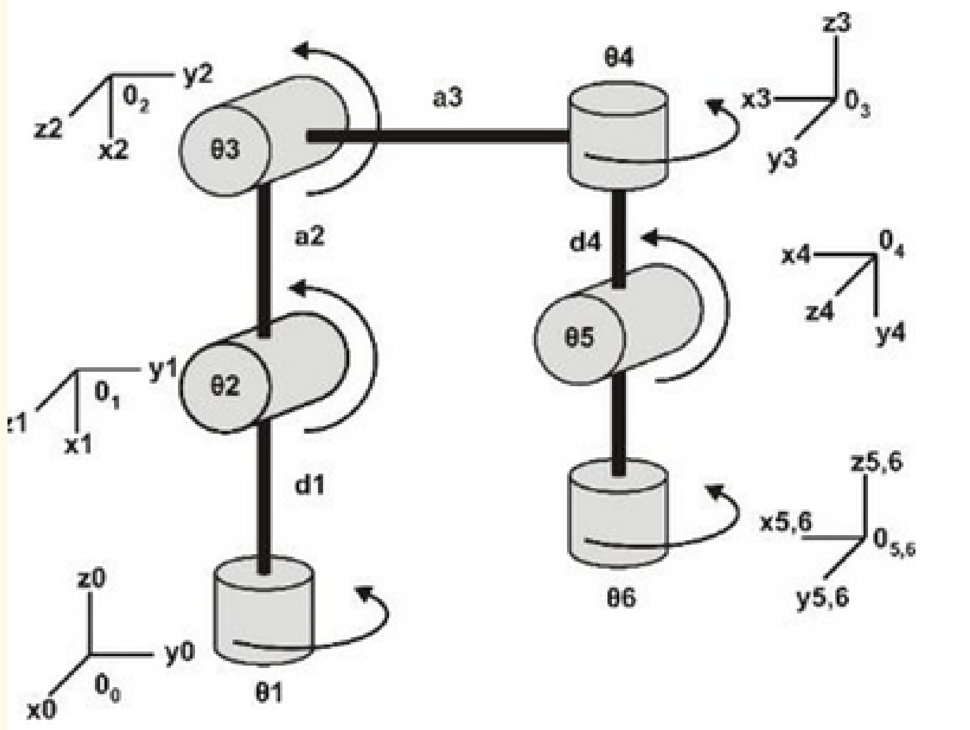
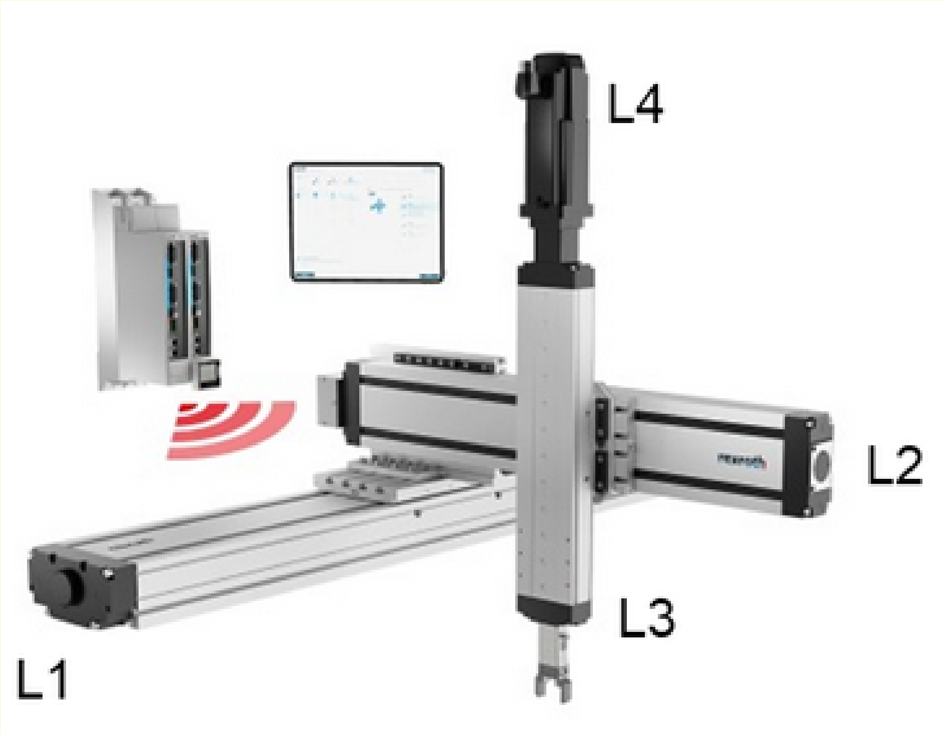


ANALISIS DE TRANSFORMACIONES



Sistema
de Interaccion

Robot
Cartesiano

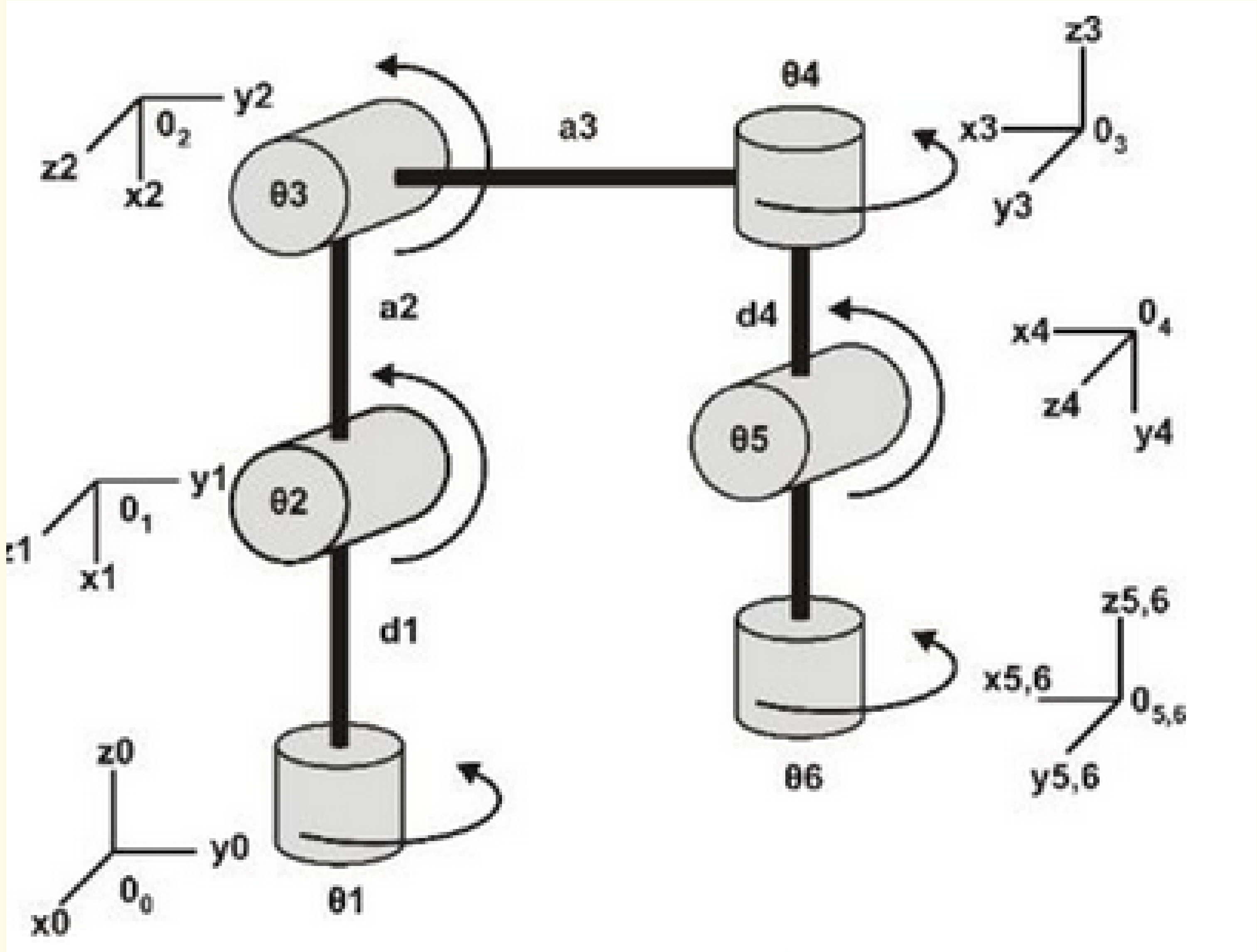


SISTEMA DE INTERACCION

I

DEFINIMOS TRANSFORMACIONES

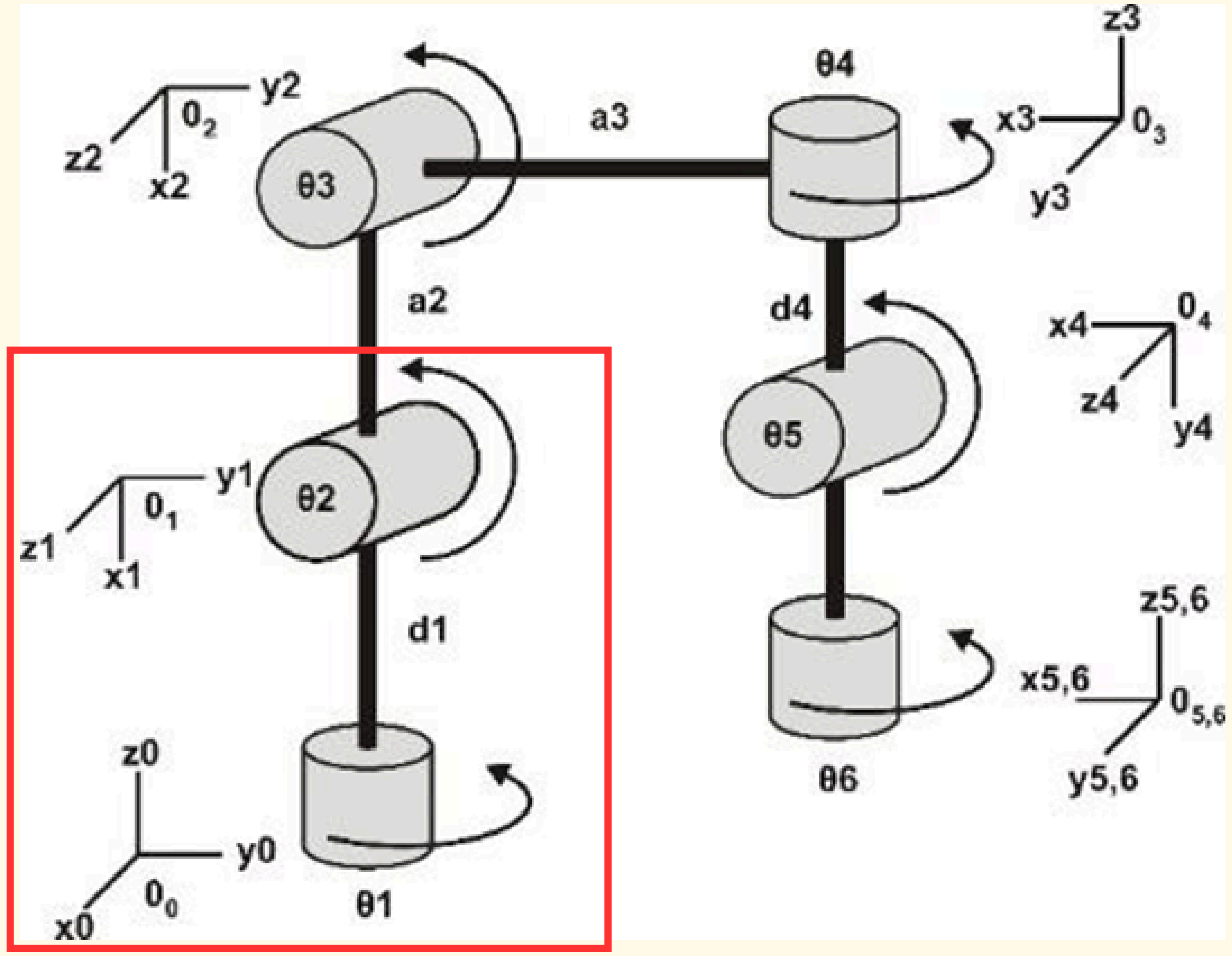
1- Rotación en Y +90
2- Sin rotación
3- Rotación en Y -90 y en Z -90
4- Rotación en X -90
5- Rotación en X +90
6- Sin rotación



SISTEMA DE INTERACCION

Articulación 1

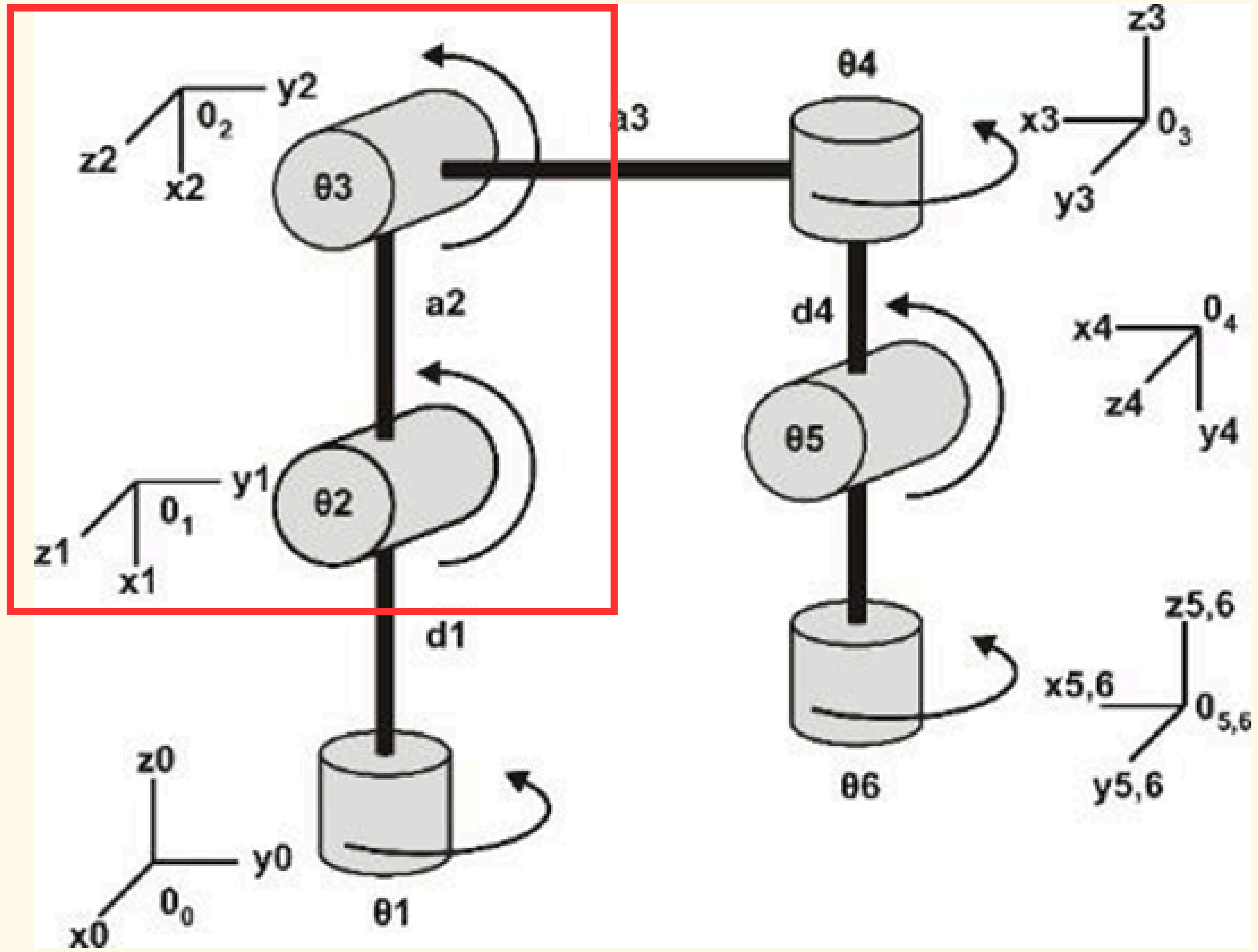
```
% Posición de la articulación 1 a 2
P(:,:,1) = [
             0;
             0;
             d1
            ];
% Matriz de rotación de la junta 1 a 2
R(:,:,1) = [
             cos(th1)   -sin(th1)     0;
             sin(th1)    cos(th1)     0;
             0           0            1
             ]*rotY(90);
```



SISTEMA DE INTERACCION

Articulación 2

```
% Posición de la articulación 2 a 3
P(:,:,2) = [
            a2*cos(th2);
            a2*sin(th2);
            0
           ];
% Matriz de rotación 2 a 3
R(:,:,2) = [
             cos(th2)   -sin(th2)     0;
             sin(th2)    cos(th2)     0;
             0           0            1
             ];
```

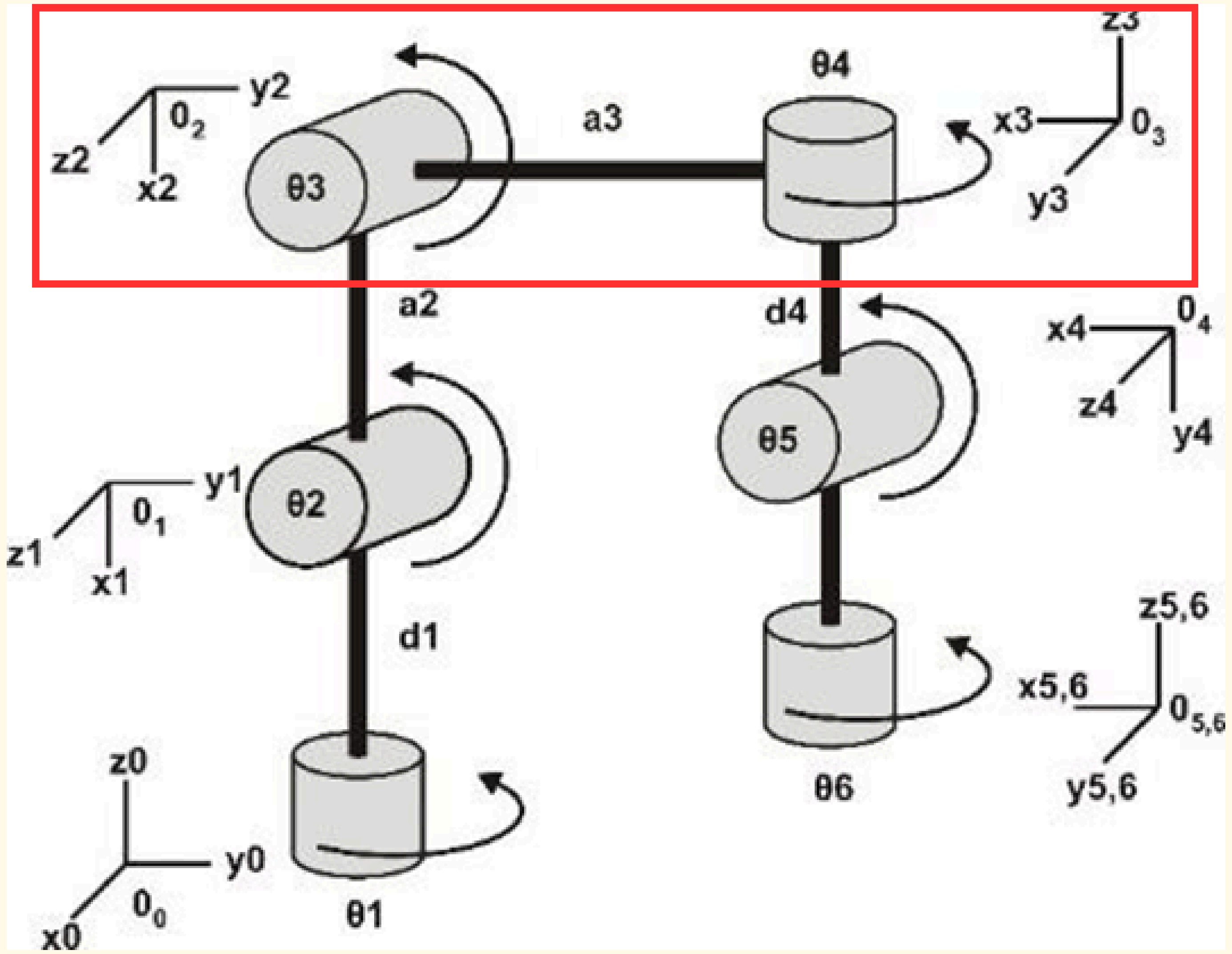


SISTEMA DE INTERACCION

Articulación 3

```
% Posición de la articulación 3 a 4
P(:,:,3) = [
            a3*cos(th3);
            a3*sin(th3);
            0
           ];

% Matriz de rotación de la junta 3 a 4
R(:,:,3) = [
            cos(th3)   -sin(th3)     0;
            sin(th3)    cos(th3)     0;
            0           0            1
            ]*rotY(-90)*rotZ(-90);
```

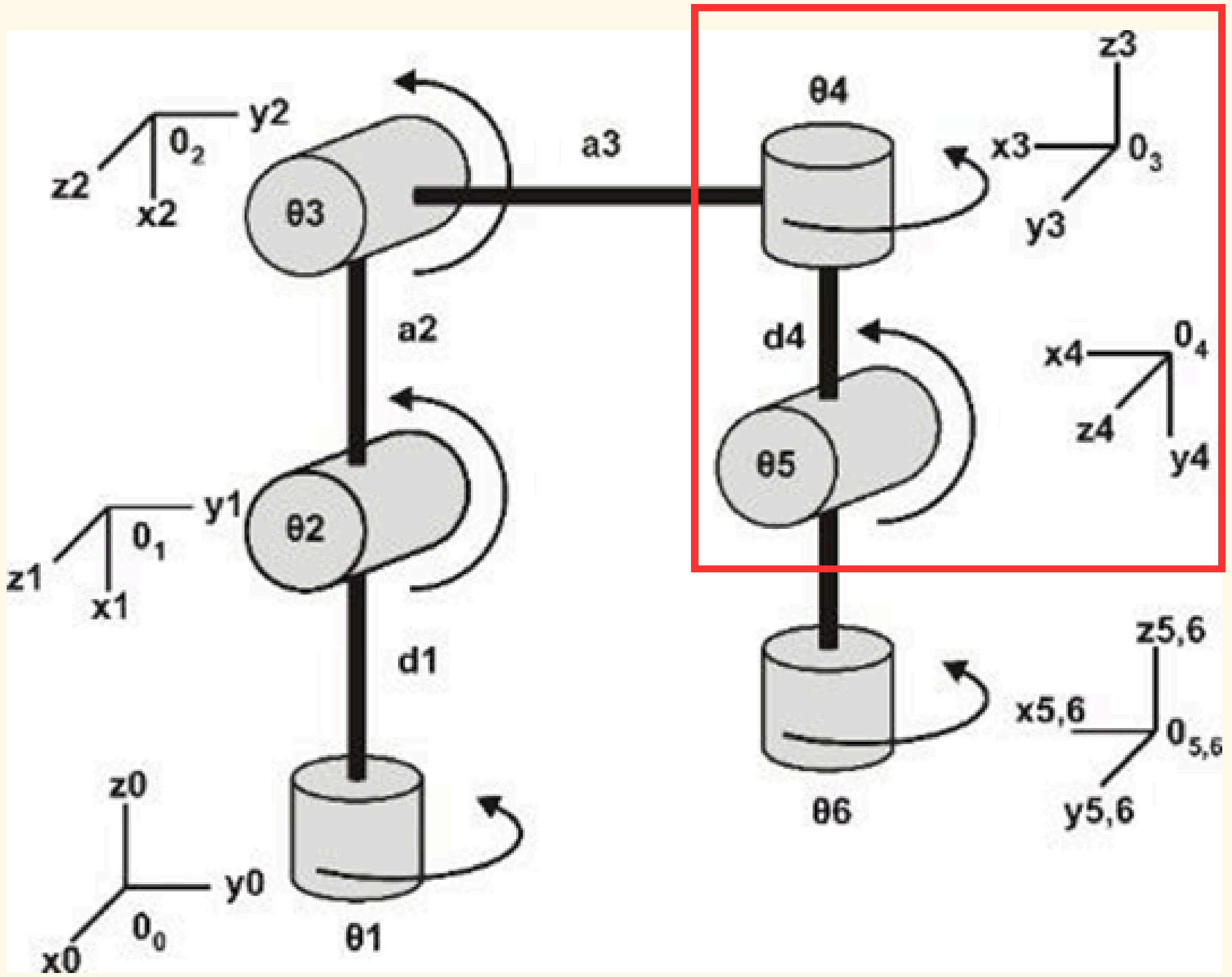


SISTEMA DE INTERACCION

Articulación 4

```
% Posición de la articulación 4 a 5
P(:,:,4) = [
             0;
             0;
            -d4
           ];

% Matriz de rotación de la junta 4 a 5
R(:,:,4) = [
             cos(th4)   -sin(th4)     0;
             sin(th4)    cos(th4)     0;
             0           0            1
             ]*rotX(-90);
```

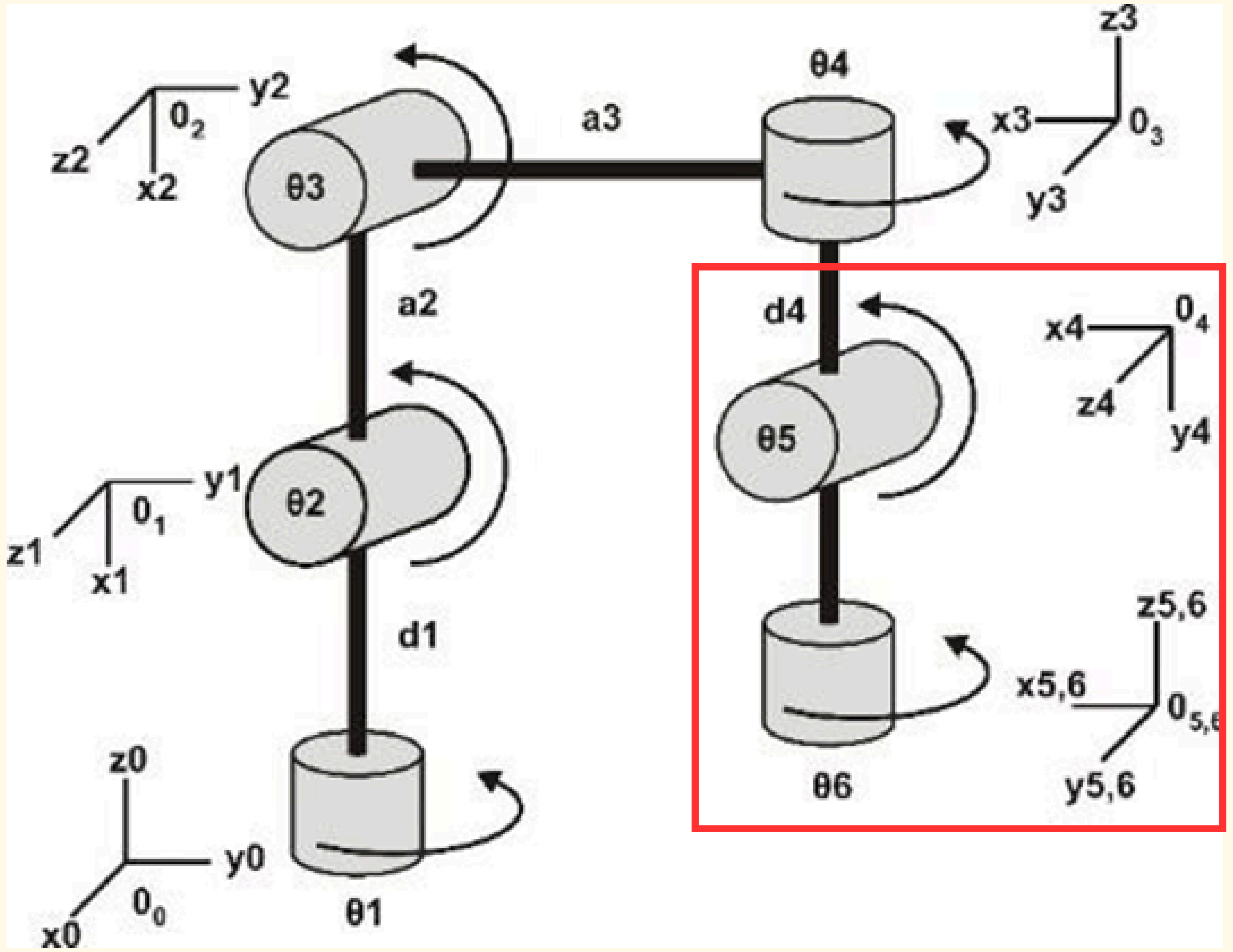


SISTEMA DE INTERACCION

Articulación 5

```matlab
% Posición de la articulación 5 a 6
P(:,:,5) = [
            l5*cos(th5);
            l5*sin(th5);
            0
           ];

% Matriz de rotación de la junta 5 a 6
R(:,:,5) = [
             cos(th5)   -sin(th5)     0;
             sin(th5)    cos(th5)     0;
             0           0            1
             ]*rotX(90);
```

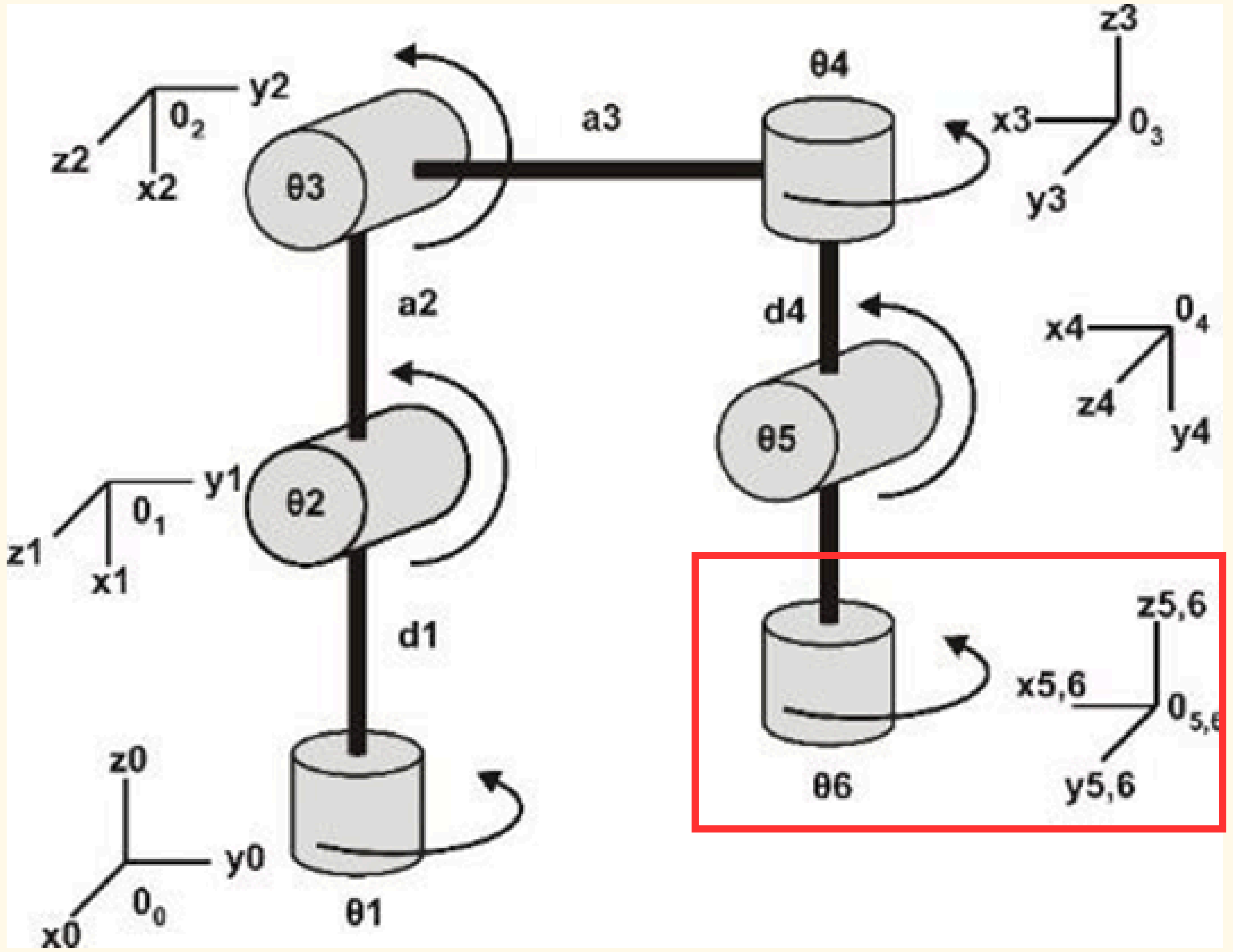


SISTEMA DE INTERACCION

Articulación 6

```
% Posición de la articulación 6
P(:,:,6) = [
            0;
            0;
            0
           ];

% Matriz de rotación de la junta 6
R(:,:,6) = [
             cos(th6)   -sin(th6)     0;
             sin(th6)    cos(th6)     0;
             0           0            1
             ];
```



VELOCIDAD LINEAL

$$\begin{pmatrix} l_5\,\sigma_6\cos(\mathrm{th}_5(t))\,\left(\cos(\mathrm{th}_1(t))\cos(\mathrm{th}_4(t)) - \sin(\mathrm{th}_1(t))\sin(\mathrm{th}_4(t))\cos(\sigma_{20})\right) - \sigma_{13}\,\left(\cos(\mathrm{th}_1(t))\,\sigma_{16} + l_5\cos(\mathrm{th}_5(t))\,\left(\sin(\mathrm{th}_1(t))\sin(\mathrm{th}_4(t)) - \cos(\mathrm{th}_1(t))\cos(\mathrm{th}_4(t))\cos(\sigma_{20})\right) + d_4\cos(\mathrm{th}_1(t))\sin(\sigma_{20}) + l_5\cos(\mathrm{th}_1(t))\sin(\mathrm{th}_5(t))\sin(\sigma_{20})\right) - \sigma_7\sin(\mathrm{th}_1(t))\,\sigma_{15} - \sigma_8\sin(\mathrm{th}_1(t))\,\sigma_{14} - \sigma_5\,\left(l_5\cos(\mathrm{th}_5(t))\sin(\mathrm{th}_1(t))\sin(\sigma_{20}) + l_5\cos(\mathrm{th}_1(t))\sin(\mathrm{th}_4(t))\sin(\mathrm{th}_5(t)) + l_5\cos(\mathrm{th}_4(t))\sin(\mathrm{th}_1(t))\sin(\mathrm{th}_5(t))\cos(\sigma_{20})\right) \\ \sigma_5\,\left(l_5\cos(\mathrm{th}_1(t))\cos(\mathrm{th}_5(t))\sin(\sigma_{20}) - l_5\sin(\mathrm{th}_1(t))\sin(\mathrm{th}_4(t))\sin(\mathrm{th}_5(t)) + l_5\cos(\mathrm{th}_1(t))\cos(\mathrm{th}_4(t))\sin(\mathrm{th}_5(t))\cos(\sigma_{20})\right) - \sigma_{13}\,\left(\sin(\mathrm{th}_1(t))\,\sigma_{16} - l_5\cos(\mathrm{th}_5(t))\,\left(\cos(\mathrm{th}_1(t))\sin(\mathrm{th}_4(t)) + \cos(\mathrm{th}_4(t))\sin(\mathrm{th}_1(t))\cos(\sigma_{20})\right) + d_4\sin(\mathrm{th}_1(t))\sin(\sigma_{20}) + l_5\sin(\mathrm{th}_1(t))\sin(\mathrm{th}_5(t))\sin(\sigma_{20})\right) + \sigma_7\cos(\mathrm{th}_1(t))\,\sigma_{15} + \sigma_8\cos(\mathrm{th}_1(t))\,\sigma_{14} + l_5\,\sigma_6\cos(\mathrm{th}_5(t))\,\left(\cos(\mathrm{th}_4(t))\sin(\mathrm{th}_1(t)) + \cos(\mathrm{th}_1(t))\sin(\mathrm{th}_4(t))\cos(\sigma_{20})\right) \\ \sigma_7\,(\sigma_{12} + \sigma_{11} + \sigma_{10} + \sigma_9 + \sigma_4 + \sigma_3 + \sigma_1 - \sigma_2) + \sigma_8\,(\sigma_{19} + \sigma_{12} + \sigma_{11} + \sigma_{10} + \sigma_9 + \sigma_4 + \sigma_3 + \sigma_1 - \sigma_2) - \sigma_5\,\left(l_5\cos(\mathrm{th}_5(t))\cos(\sigma_{20}) - l_5\cos(\mathrm{th}_4(t))\sin(\mathrm{th}_5(t))\sin(\sigma_{20})\right) + l_5\,\sigma_6\cos(\mathrm{th}_5(t))\sin(\mathrm{th}_4(t))\sin(\sigma_{20}) \end{pmatrix}$$

where

$$\sigma_1 = l_5\cos(\mathrm{th}_4(t))\cos(\mathrm{th}_5(t))\sin(\mathrm{th}_2(t))\sin(\mathrm{th}_3(t))$$

$$\sigma_2 = l_5\cos(\mathrm{th}_2(t))\cos(\mathrm{th}_3(t))\cos(\mathrm{th}_4(t))\cos(\mathrm{th}_5(t))$$

$$\sigma_3 = l_5\cos(\mathrm{th}_3(t))\sin(\mathrm{th}_2(t))\sin(\mathrm{th}_5(t))$$

$$\sigma_4 = l_5\cos(\mathrm{th}_2(t))\sin(\mathrm{th}_3(t))\sin(\mathrm{th}_5(t))$$

$$\sigma_5 = \overline{\frac{\partial}{\partial t}\ \mathrm{th}_5(t)}$$

$$\sigma_6 = \overline{\frac{\partial}{\partial t}\ \mathrm{th}_4(t)}$$

$$\sigma_7 = \overline{\frac{\partial}{\partial t}\ \mathrm{th}_3(t)}$$

$$\sigma_8 = \overline{\frac{\partial}{\partial t}\ \mathrm{th}_2(t)}$$

$$\sigma_9 = d_4\cos(\mathrm{th}_3(t))\sin(\mathrm{th}_2(t))$$

$$\sigma_{10} = d_4\cos(\mathrm{th}_2(t))\sin(\mathrm{th}_3(t))$$

$$\sigma_{11} = a_3\cos(\mathrm{th}_3(t))\sin(\mathrm{th}_2(t))$$

$$\sigma_{12} = a_3\cos(\mathrm{th}_2(t))\sin(\mathrm{th}_3(t))$$

$$\sigma_{13} = \overline{\frac{\partial}{\partial t}\ \mathrm{th}_1(t)}$$

$$\sigma_{14} = a_2\cos(\mathrm{th}_2(t)) + a_3\cos(\sigma_{20}) + d_4\cos(\sigma_{20}) + \sigma_{18} + \sigma_{17}$$

$$\sigma_{15} = a_3\cos(\sigma_{20}) + d_4\cos(\sigma_{20}) + \sigma_{18} + \sigma_{17}$$

$$\sigma_{16} = \sigma_{19} + a_3\sin(\sigma_{20})$$

$$\sigma_{17} = l_5\cos(\mathrm{th}_4(t))\cos(\mathrm{th}_5(t))\sin(\sigma_{20})$$

$$\sigma_{18} = l_5\sin(\mathrm{th}_5(t))\cos(\sigma_{20})$$

$$\sigma_{19} = a_2\sin(\mathrm{th}_2(t))$$

$$\sigma_{20} = \mathrm{th}_2(t) + \mathrm{th}_3(t)$$

VELOCIDAD ANGULAR

$$\begin{pmatrix} \sigma_1 \, (\sin(\mathrm{th}_5(t)) \, (\cos(\mathrm{th}_1(t)) \sin(\mathrm{th}_4(t)) + \cos(\mathrm{th}_4(t)) \sin(\mathrm{th}_1(t)) \cos(\sigma_4)) + \cos(\mathrm{th}_5(t)) \sin(\mathrm{th}_1(t)) \sin(\sigma_4)) + \sigma_2 \, (\cos(\mathrm{th}_1(t)) \cos(\mathrm{th}_4(t)) - \sin(\mathrm{th}_1(t)) \sin(\mathrm{th}_4(t)) \cos(\sigma_4)) + \sigma_6 \cos(\mathrm{th}_1(t)) + \sigma_5 \cos(\mathrm{th}_1(t)) + \sigma_3 \sin(\mathrm{th}_1(t)) \sin(\sigma_4) \\ \sigma_1 \, (\sin(\mathrm{th}_5(t)) \, (\sin(\mathrm{th}_1(t)) \sin(\mathrm{th}_4(t)) - \cos(\mathrm{th}_1(t)) \cos(\mathrm{th}_4(t)) \cos(\sigma_4)) - \cos(\mathrm{th}_1(t)) \cos(\mathrm{th}_5(t)) \sin(\sigma_4)) + \sigma_2 \, (\cos(\mathrm{th}_4(t)) \sin(\mathrm{th}_1(t)) + \cos(\mathrm{th}_1(t)) \sin(\mathrm{th}_4(t)) \cos(\sigma_4)) + \sigma_6 \sin(\mathrm{th}_1(t)) + \sigma_5 \sin(\mathrm{th}_1(t)) - \sigma_3 \cos(\mathrm{th}_1(t)) \sin(\sigma_4) \\ \overline{\frac{\partial}{\partial t} \, \mathrm{th}_1(t)} + \sigma_3 \cos(\sigma_4) + \sigma_1 \, (\cos(\mathrm{th}_5(t)) \cos(\sigma_4) - \cos(\mathrm{th}_4(t)) \sin(\mathrm{th}_5(t)) \sin(\sigma_4)) + \sigma_2 \sin(\mathrm{th}_4(t)) \sin(\sigma_4) \end{pmatrix}$$

where

$$\sigma_1 = \overline{\frac{\partial}{\partial t} \, \mathrm{th}_6(t)}$$

$$\sigma_2 = \overline{\frac{\partial}{\partial t} \, \mathrm{th}_5(t)}$$

$$\sigma_3 = \overline{\frac{\partial}{\partial t} \, \mathrm{th}_4(t)}$$

$$\sigma_4 = \mathrm{th}_2(t) + \mathrm{th}_3(t)$$

$$\sigma_5 = \overline{\frac{\partial}{\partial t} \, \mathrm{th}_3(t)}$$

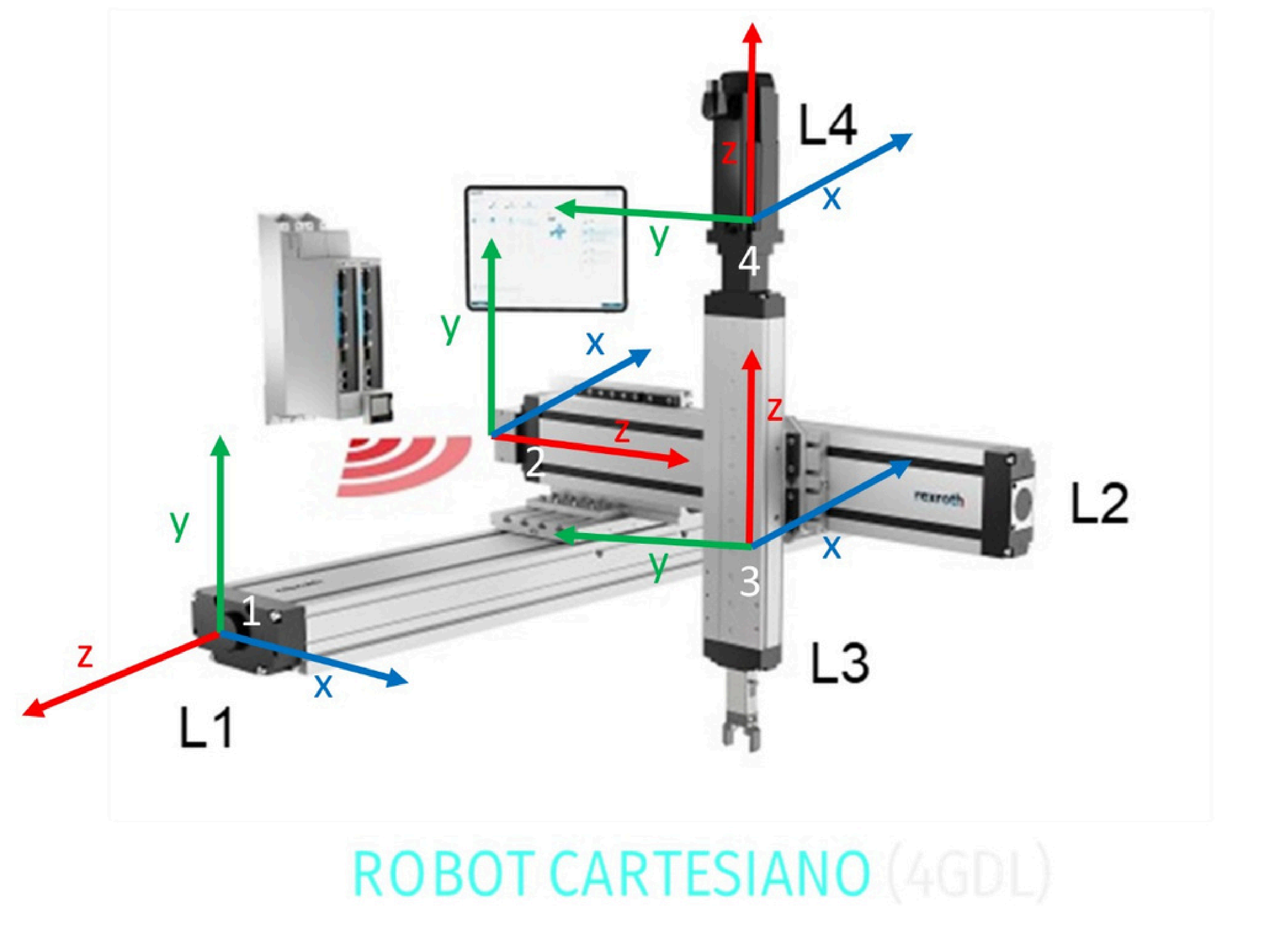
$$\sigma_6 = \overline{\frac{\partial}{\partial t} \, \mathrm{th}_2(t)}$$

ROBOT CARTESIANO

2

DEFINIMOS NUESTROS EJES

1- Rotación en Y +90
2- Rotación en X -90
3- Sin rotación
4- Sin rotación



ROBOT CARTESIANO

Articulación 1

Posición de la articulación 1 respecto a 0

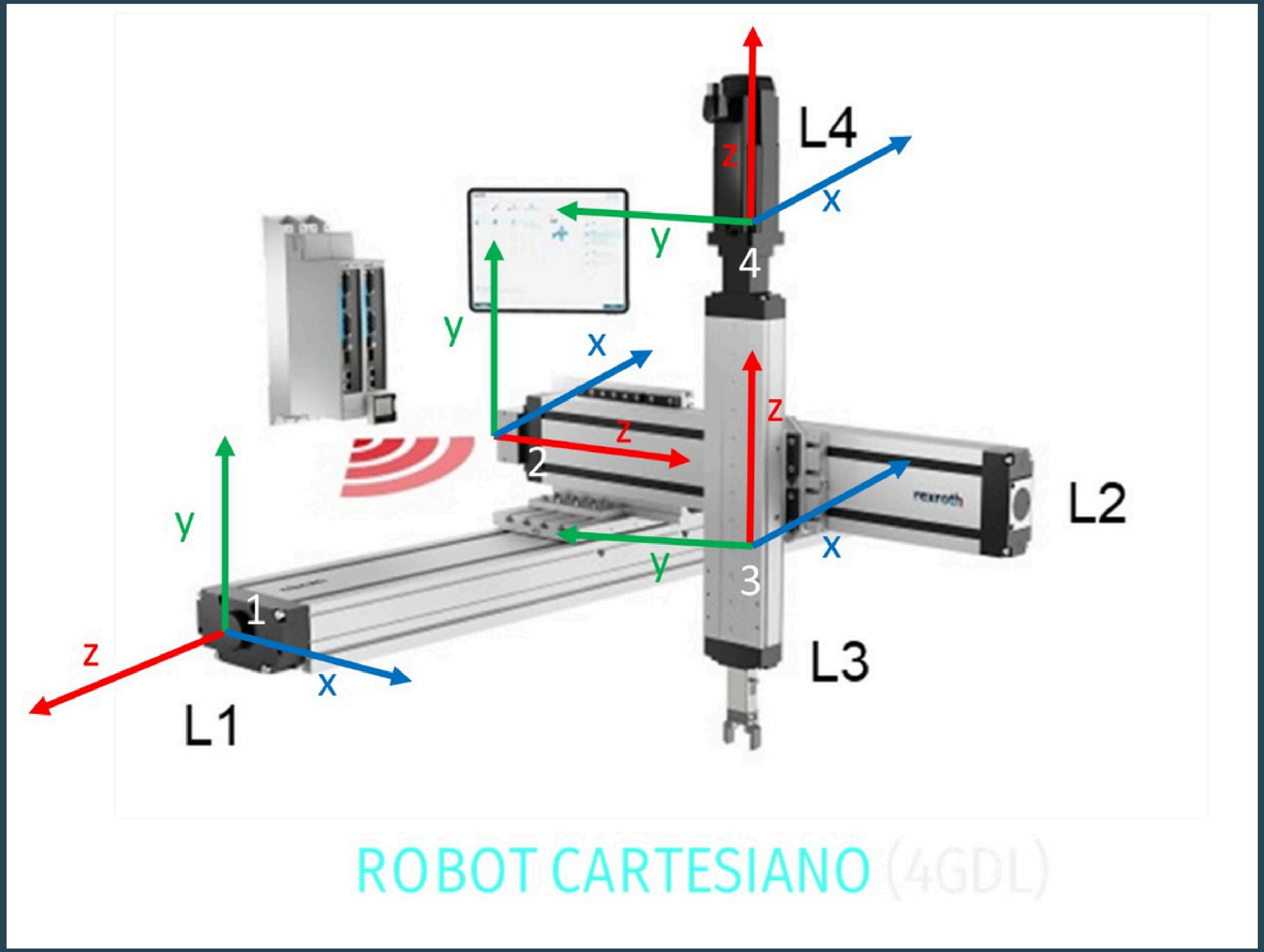
```
P(:,:,1) = [
           0;
           0;
           l1
          ];
```

Matriz de rotación de la junta 1 respecto a 0

```
R(:,:,1) = rotY(90)
```

```
R = 3×3

     0     0     1
     0     1     0
    -1     0     0
```



ROBOT CARTESIANO

Articulacion 2

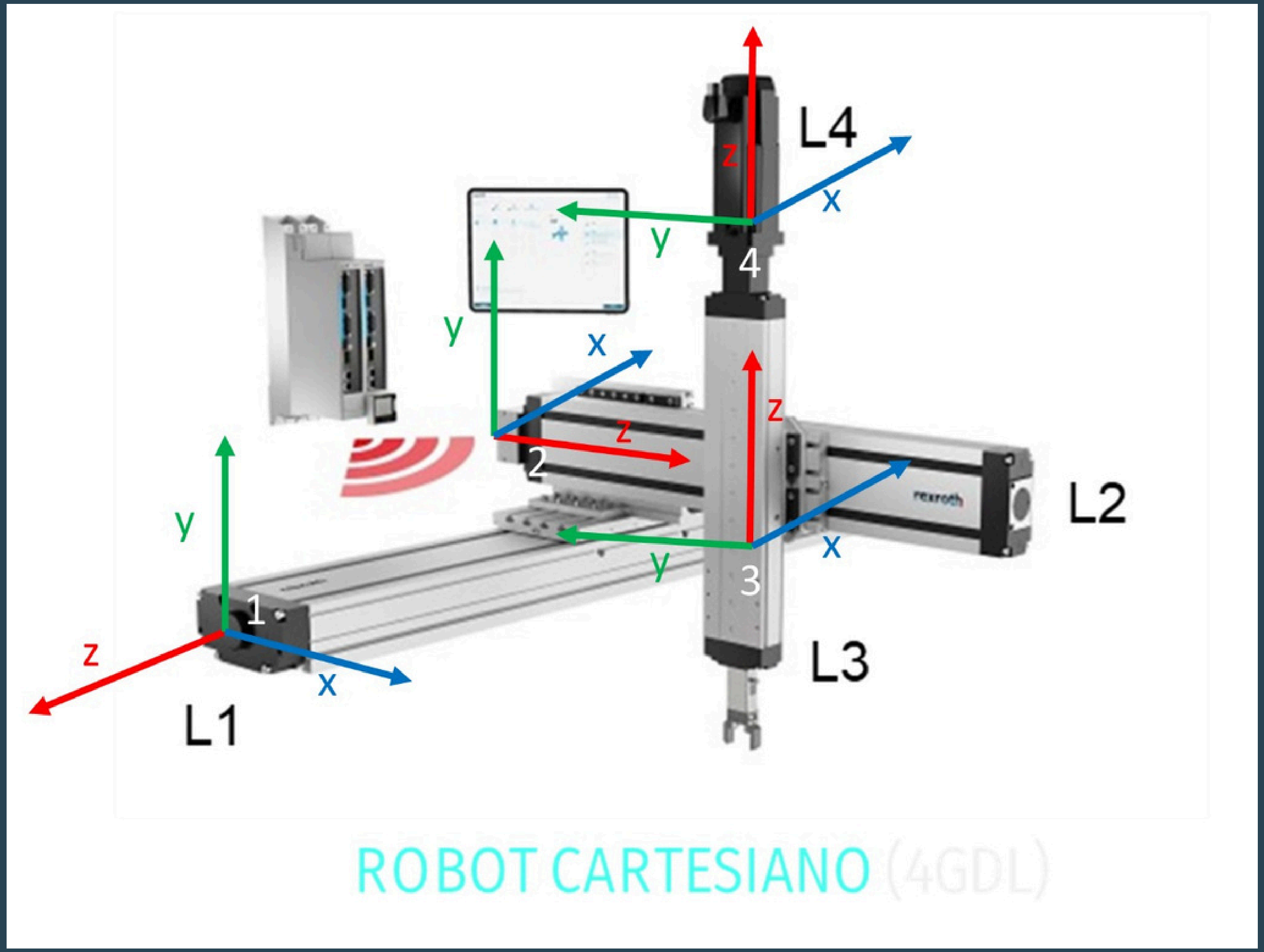
Posición de la articulación 2 respecto a 1

```
P(:,:,2) = [
             0;
             0;
             l2
            ];
```

Matriz de rotación de la junta 2 respecto a 1

```
R(:,:,2) = rotX(-90); R(:,:,2)
```

```
ans = 3×3
     1     0     0
     0     0     1
     0    -1     0
```



ROBOT CARTESIANO

Articulacion 3

Posición de la articulación 3 respecto a la 2

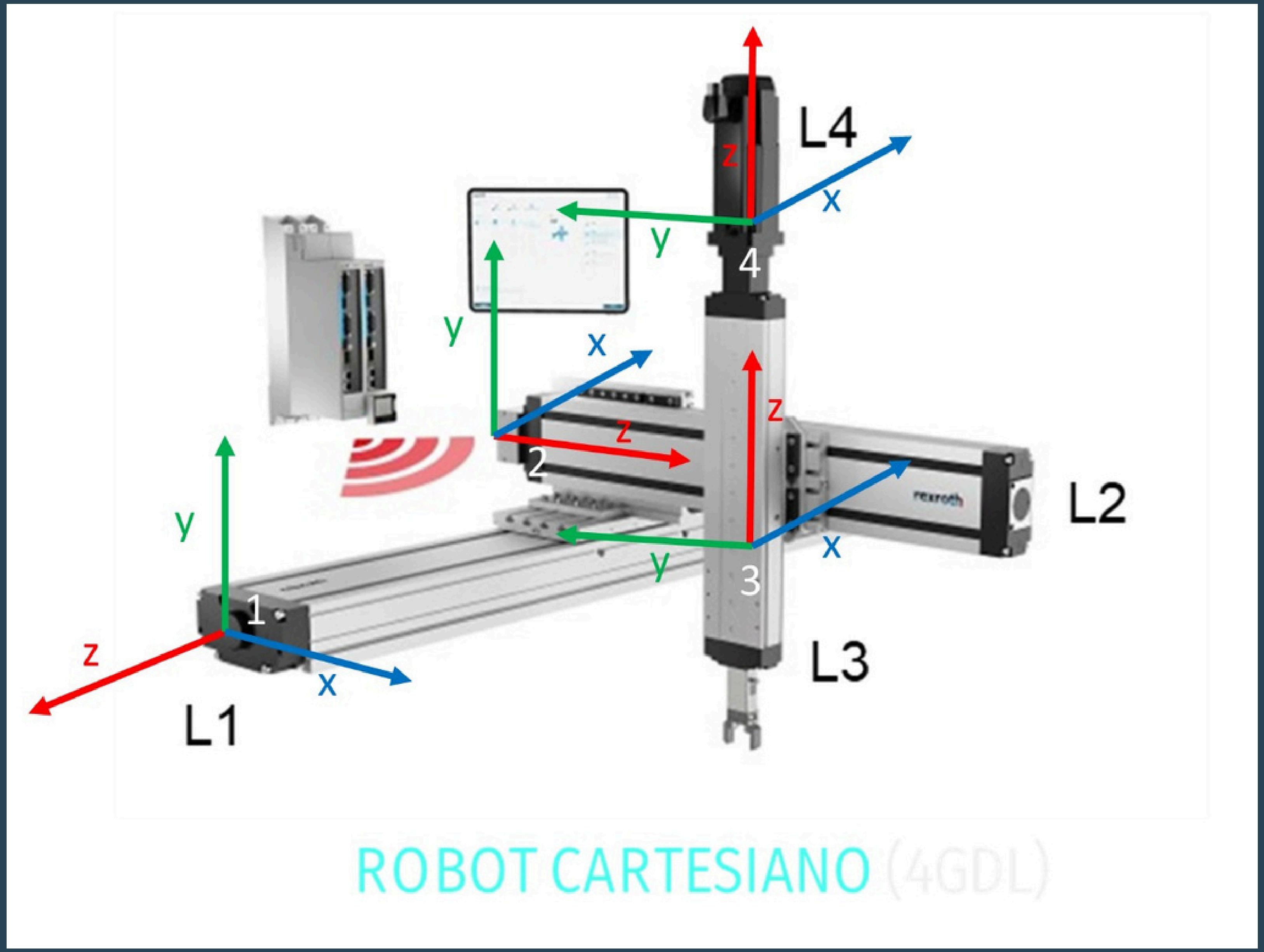
```
P(:,:,3) = [
            0;
            0;
            l3
           ];
```

Matriz de rotación de la junta 3 respecto a la 2 0°

```
R(:,:,3) = rotZ(0); R(:,:,3)
```

```
ans = 3x3

     1     0     0
     0     1     0
     0     0     1
```



ROBOT CARTESIANO

Articulacion 4

Posición de la articulación 4 respecto a la 3

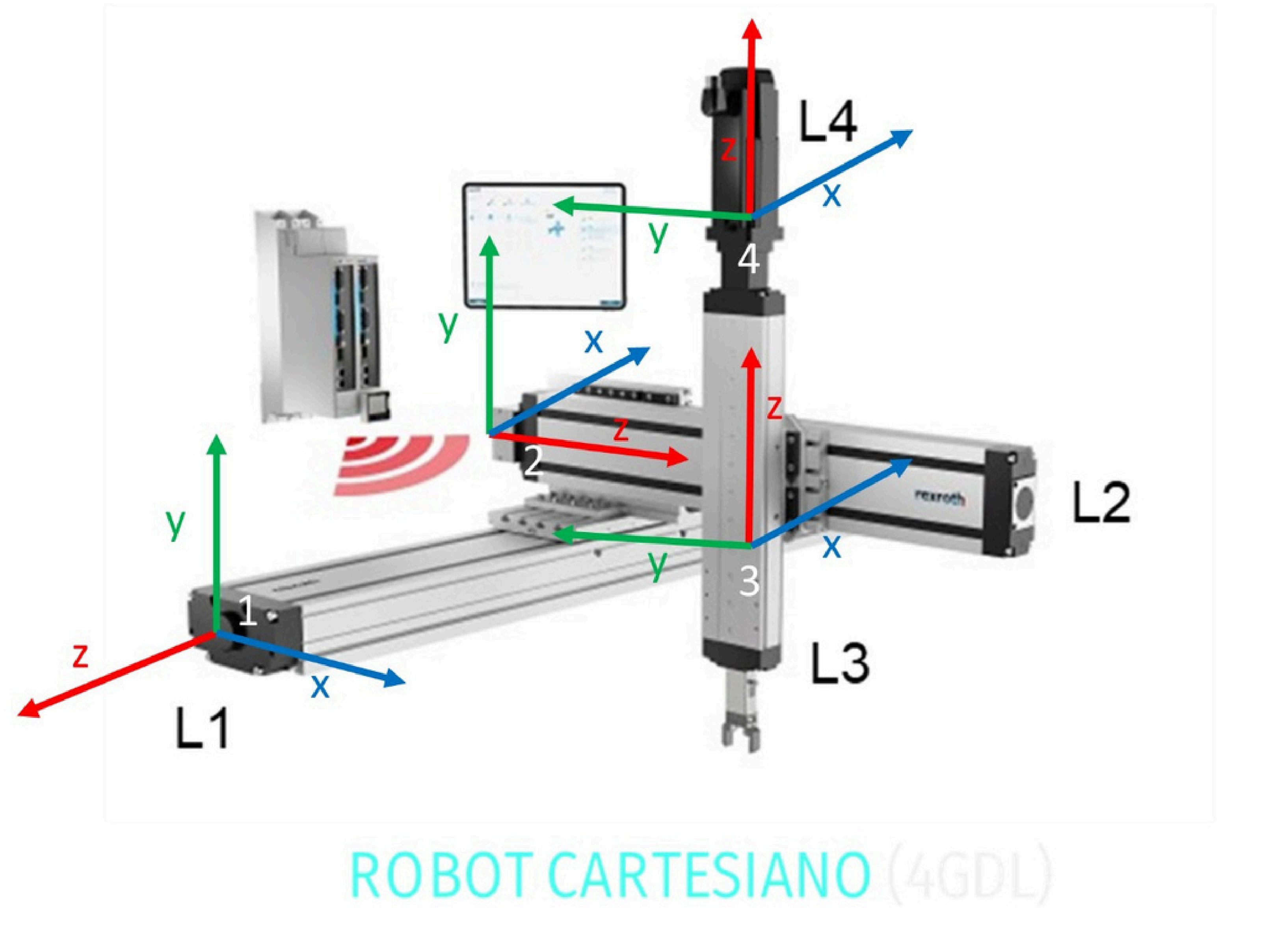
```
P(:,:,4) = [
            0;
            0;
            l4
           ];
```

Matriz de rotación de la junta 4 respecto a la 4 0°

```
R(:,:,4) = rotZ(0); R(:,:,4)
```

```
ans = 3x3

     1     0     0
     0     1     0
     0     0     1
```



VELOCIDADES

Velocidad lineal

$$\begin{pmatrix} \overline{\frac{\partial}{\partial t} l_2(t)} \\ \overline{\frac{\partial}{\partial t} l_3(t)} + \overline{\frac{\partial}{\partial t} l_4(t)} \\ \overline{\frac{\partial}{\partial t} l_1(t)} \end{pmatrix}$$

Velocidad angular

$$\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

GRACIAS