Cairo University

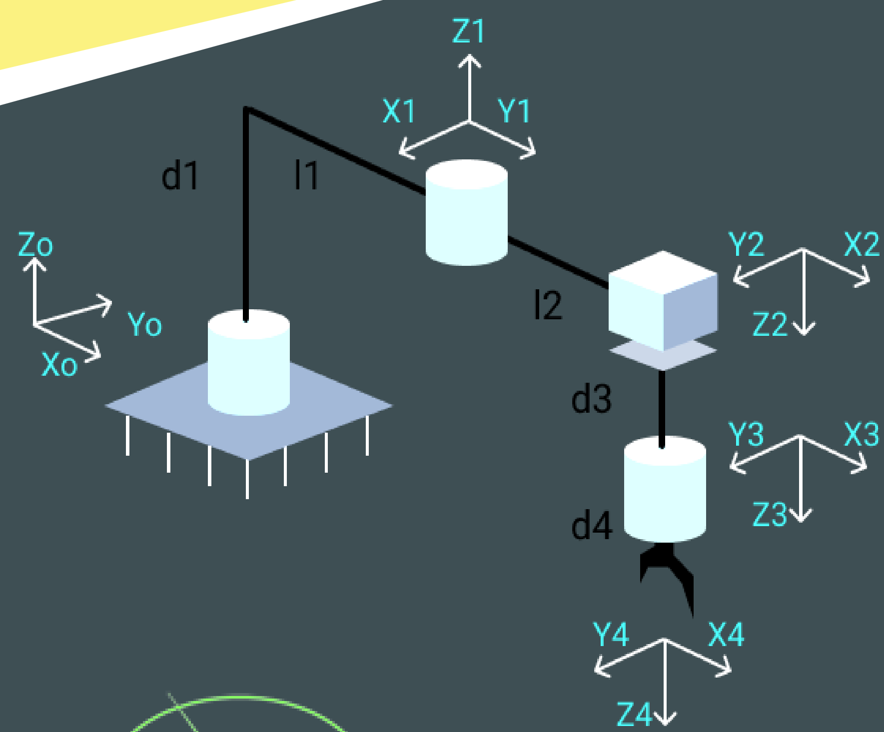
Faculty of Engineering

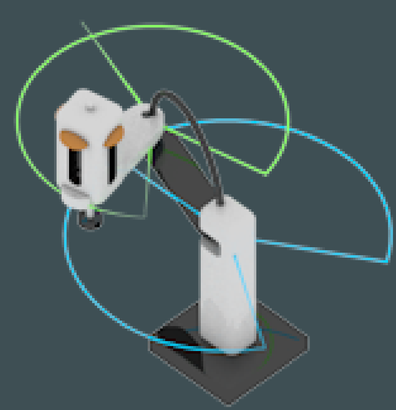
Computer Engineering

First Year

Scara Robot

Supervised by: Dr. Mohamed Elgamil





Team members:

- Mostafa Wael
- Hossam Saeed
- Taher Mohamed
- Raghed Khaled
- Nada Elsayed

Specifications

model	SR-6ia	
type	Scara Type	
controlled axes	4 Axes(J1,J2,J3,J4)	
Reach	650 mm	
Installation	Floor, Wall	
motion range (Maximum speed)	J1 axis	± 148° (440 ° /s) 2.58 rad (7.68 rad/s)
	J2 axis	±150° (700°/s) ±2.62 rad (12.22 rad/s)
	J3 stroke	210 mm (2000mm/s)
	J4 axis	±720(2500°/s) 12.57 rad (43.63 rad/s)
cycle time	0.29 s	
maximum load capacity at wrist	6 Kg	
allowable load inertia at wrist	J4 axis	0.12 Kg.m^2
repeatability	J1 + J2 axes	±0.01 mm
	J3 stroke	±0.01 mm
	J4 axis	±0.004°
j3 axis maximum push down force	200 N	
cables and air for user	Standard	RL*4/RO*4, ϕ6mm*1, ϕ 4mm*1.
	Option	RL*4, ϕ6mm*1, solenoid value*2.
mass	30 Kg.	
installation environment	Ambient temperature: 0 to 45° c. Ambient humidity: • Normally 75%RH or less (No dew nor frost allowed). • Short term 95%RH or less (within one month). Vibration acceleration: 4.9 m^2/s (0.5G) or less.	

Calculations

According to the principle of DH method, for any robot there are four structural parameters.
They are, respectively, linkage length di, joint length ri, torsion angle αi and joint angle theta i.
These parameters are defined as follows:

(1) d_i is the translation of the axis of x_{i-1} to x_i, along z_{i-1}.
(2) r_i is the translation of the axis of z_{i-1} to z_i, along x_{i-1}.
(3) α_i is the rotation angle between the axis of z_i and z_{i-1}, about x_{i-1}.
(4) ϑ_i is the rotation angle between the axis of x_{i-1} and x_i,.

The DH parameters of the SCARA robot are shown in the following Table, where *the parameters superscripted with an asterisk are variables.*
L1 =350mm, L2 = 300mm, d1 = 175mm, d4=15mm.

Link	R	α	Θ	d
1	L1	0	$\Theta1^*$	d1
2	L2	180	$\Theta2^*$	0
3	0	0	0	$d3^*$
4	0	0	Θ4*	d4

The matrices representing the pose (position and orientation) are as follows where A_i is the pose matrix opposite to link number “i”:

$$A1=\begin{bmatrix} C\theta1 & -S\theta1 & 0 & L1*C\theta1 \\ S\theta1 & C\theta1 & 0 & L1*S\theta1 \\ 0 & 0 & 1 & d1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A2=\begin{bmatrix} C\theta2 & S\theta2 & 0 & L2*C\theta2 \\ S\theta2 & -C\theta2 & 0 & L2*S\theta2 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A3=\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A4=\begin{bmatrix} C\theta4 & -S\theta4 & 0 & 0 \\ S\theta4 & C\theta2 & 0 & 0 \\ 0 & 0 & 1 & d4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A1*A2=\begin{bmatrix} C(\theta1+\theta2) & S(\theta1+\theta2) & 0 & L1*C\theta1+L2*C(\theta1+\theta2) \\ S(\theta1+\theta2) & -C(\theta1+\theta2) & 0 & L1*S\theta1+L2*S(\theta1+\theta2) \\ 0 & 0 & -1 & d1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A3*A4=\begin{bmatrix} C\theta4 & -S\theta4 & 0 & 0 \\ S\theta4 & C\theta2 & 0 & 0 \\ 0 & 0 & 1 & d3+d4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

T=A1*A2*A3*A4=

$$\begin{bmatrix} C(\theta1+\theta2-\theta4) & S(\theta1+\theta2-\theta4) & 0 & L1*C\theta1+L2*C(\theta1+\theta2) \\ S(\theta1+\theta2-\theta4) & -C(\theta1+\theta2-\theta4) & 0 & L1*S\theta1+L2*S(\theta1+\theta2) \\ 0 & 0 & -1 & d1-d3-d4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

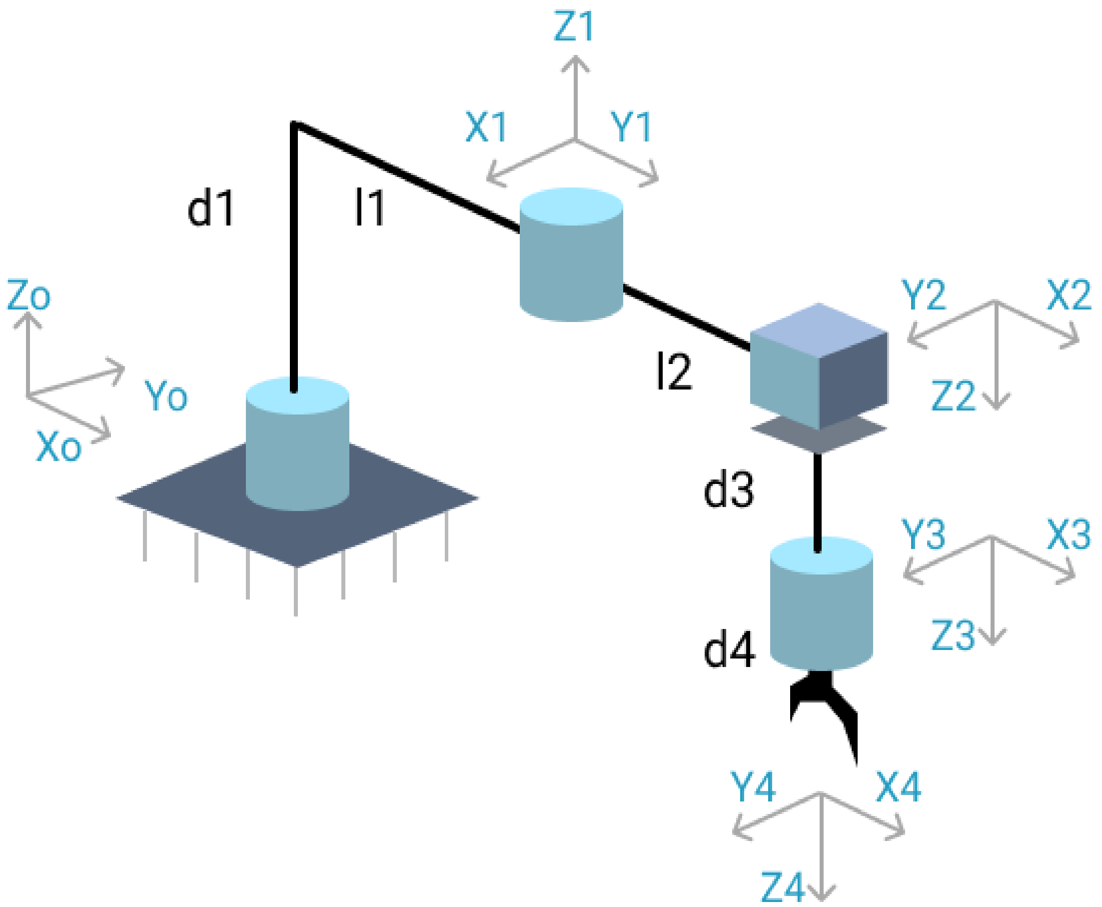
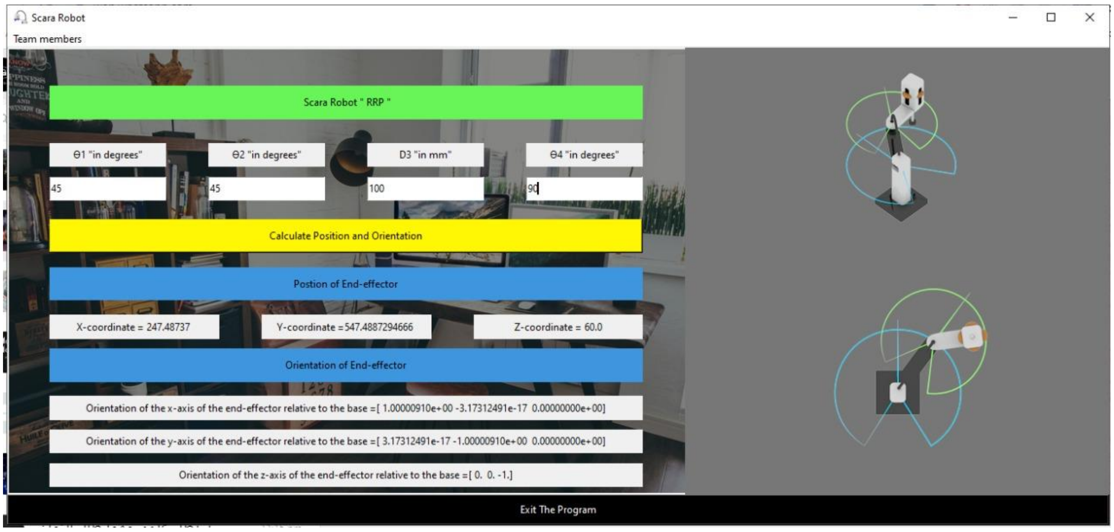
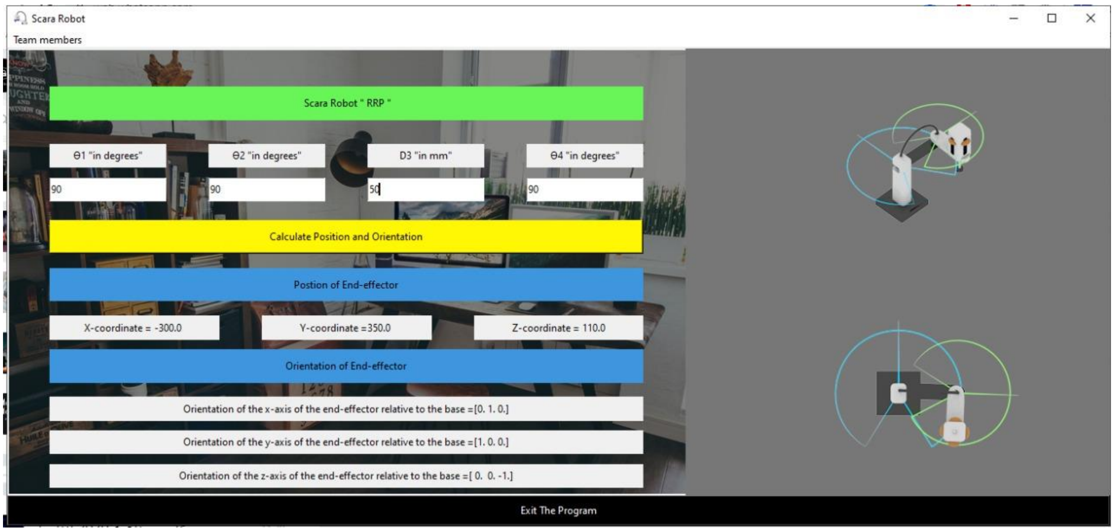


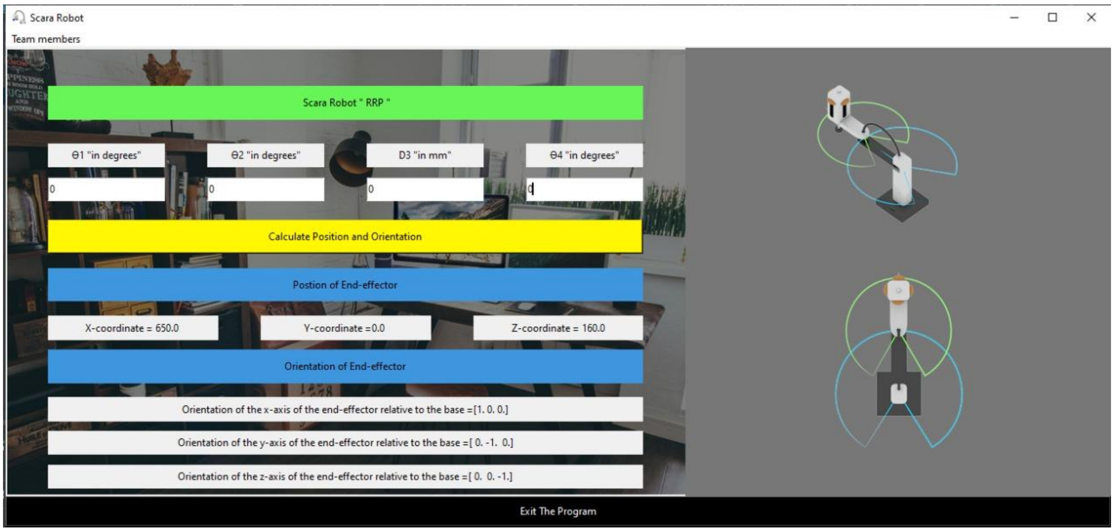
Figure-1 joint coordinates

Test cases from the program

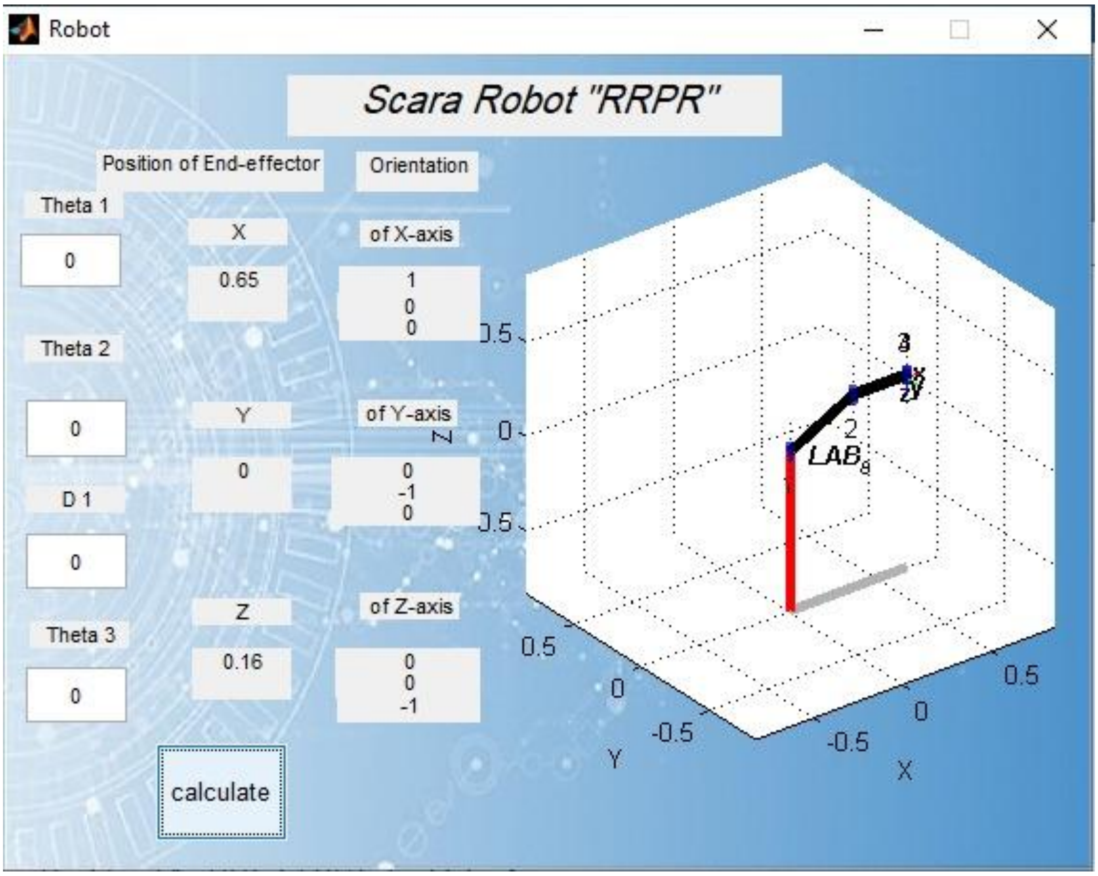
1. Python code.

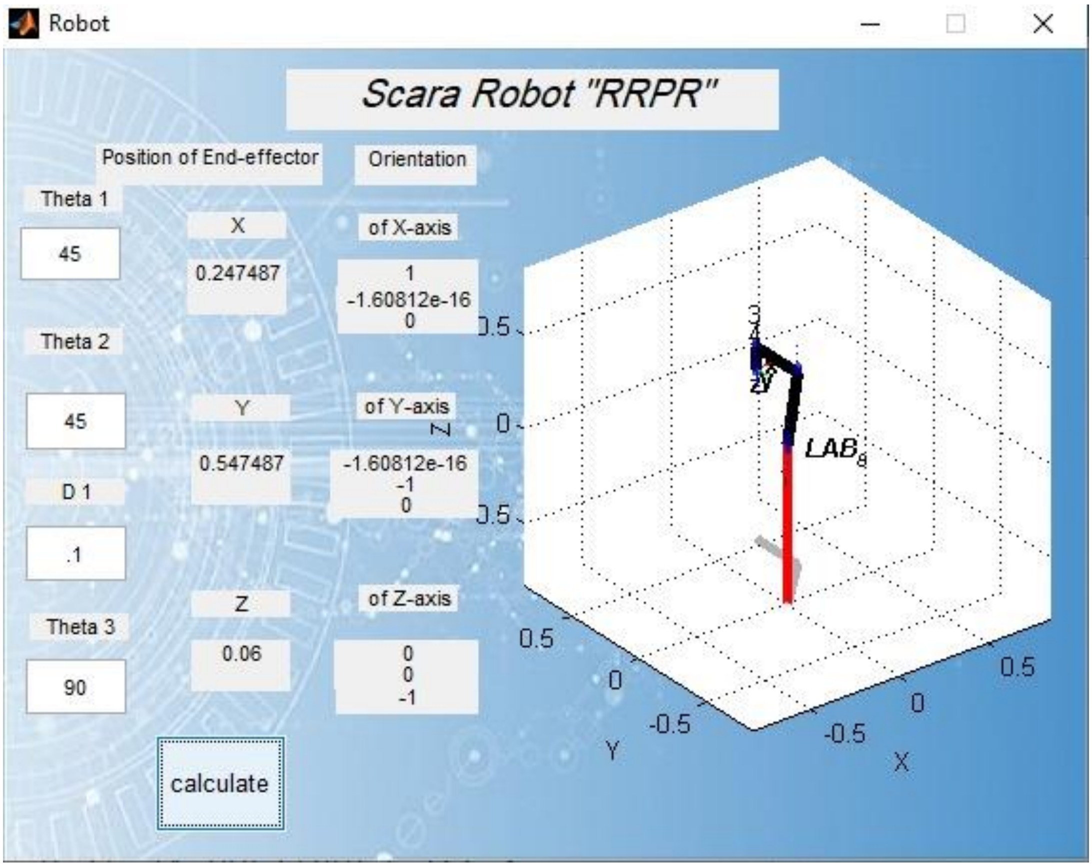


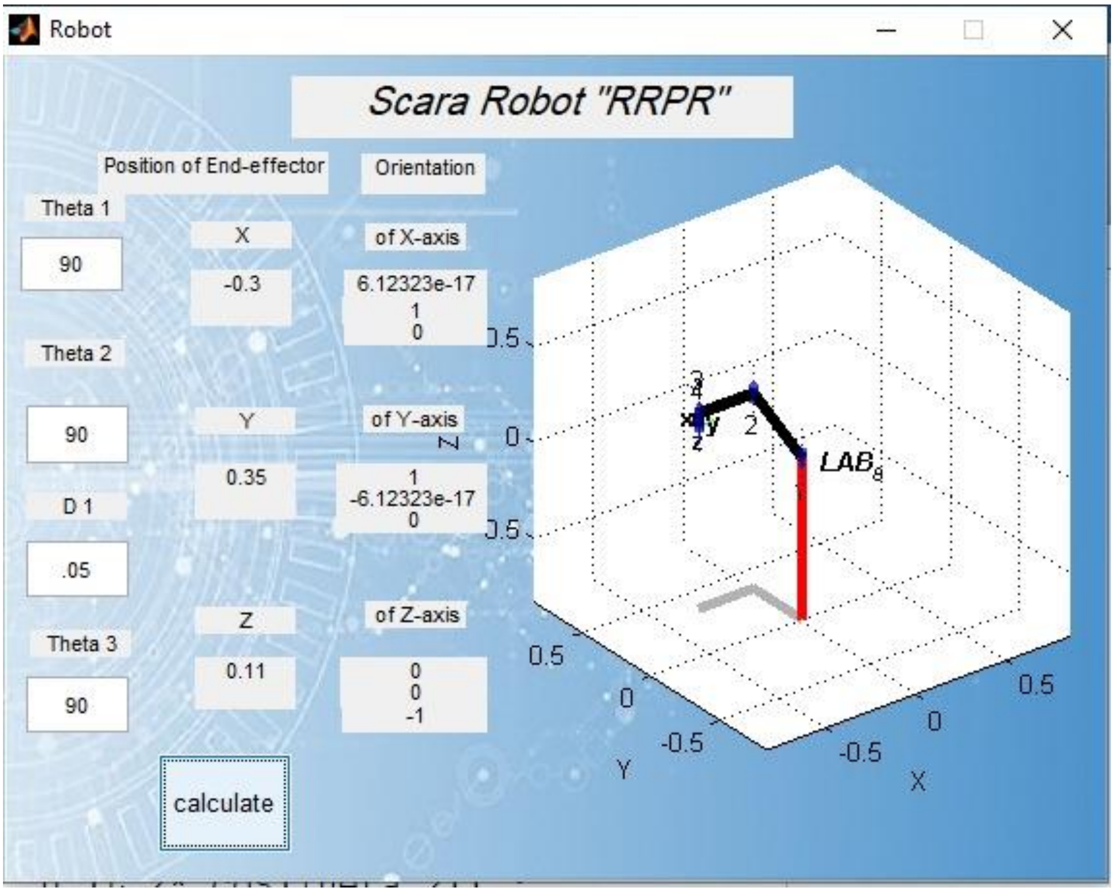




2. MATLAB code.







References

- Tsai, L., 1999. *Robot Analysis*. New York: John Wiley.
- https://www.fanuc.com/fvl/vn/product/catalog/RSCARA(E)-03.pdf