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Robot Morphology

Location of RTB robot manipulator models: `.../MatlabDrive/RVC2/rvctools/robot/models`

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6R Robot. Puma 560

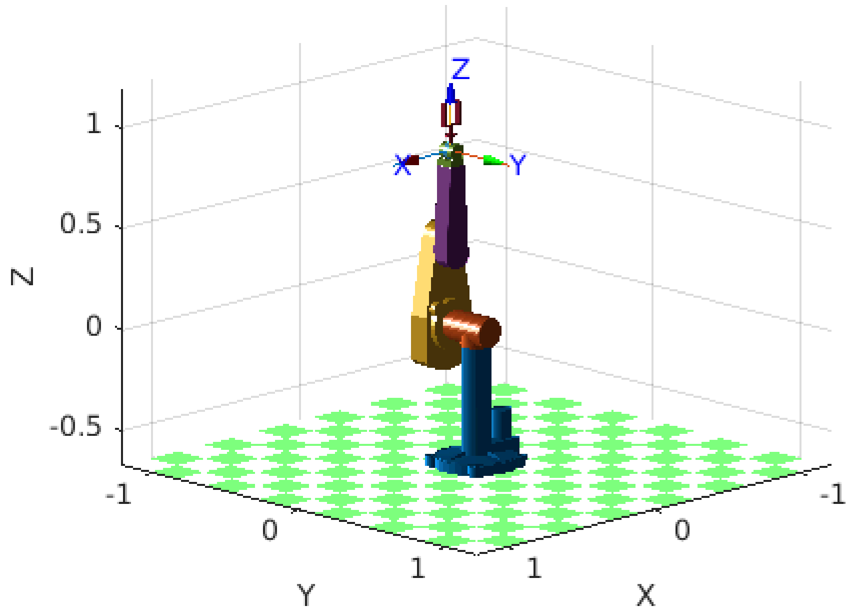
Before start the exercise see the videos:

- https://youtu.be/ArzP7rh4_9Q (shows the robot is a 6R) and
- https://youtu.be/aHV5oY7viBM (the 6R drawing)

Call the robot object and plot it

```
close all
clear
mdl_puma560 % Invoque the puma object
p560.plot3d(qr) % qz is the joint vector 1x6. Try qr, qn, any within the limits
```

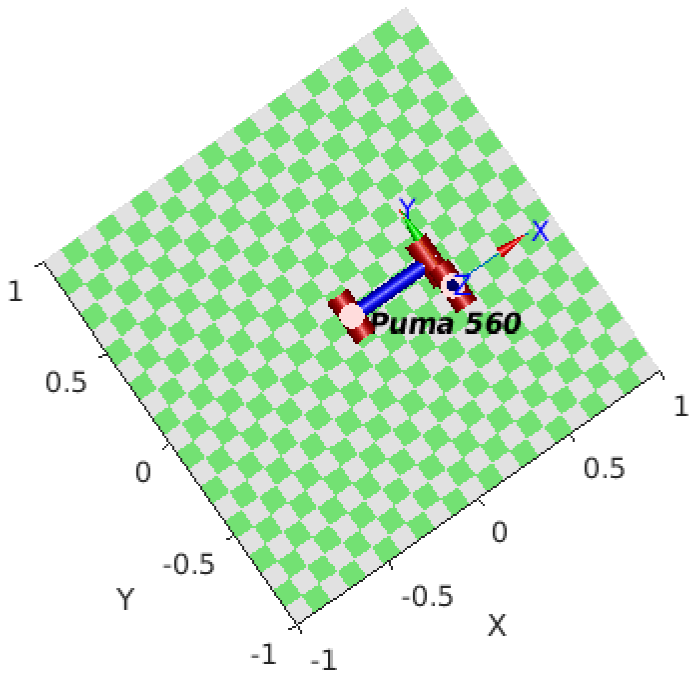
```
Loading STL models from ARTE Robotics Toolbox for Education  by Arturo Gil (http://arvc.umh.es/arte)......
```



Work with the wire model and change the point of view.

See: https://es.mathworks.com/help/matlab/creating_plots/setting-the-viewpoint-with-azimuth-and-elevation.html

```
close all
p560.plot(qz)
view([-35 90])
```

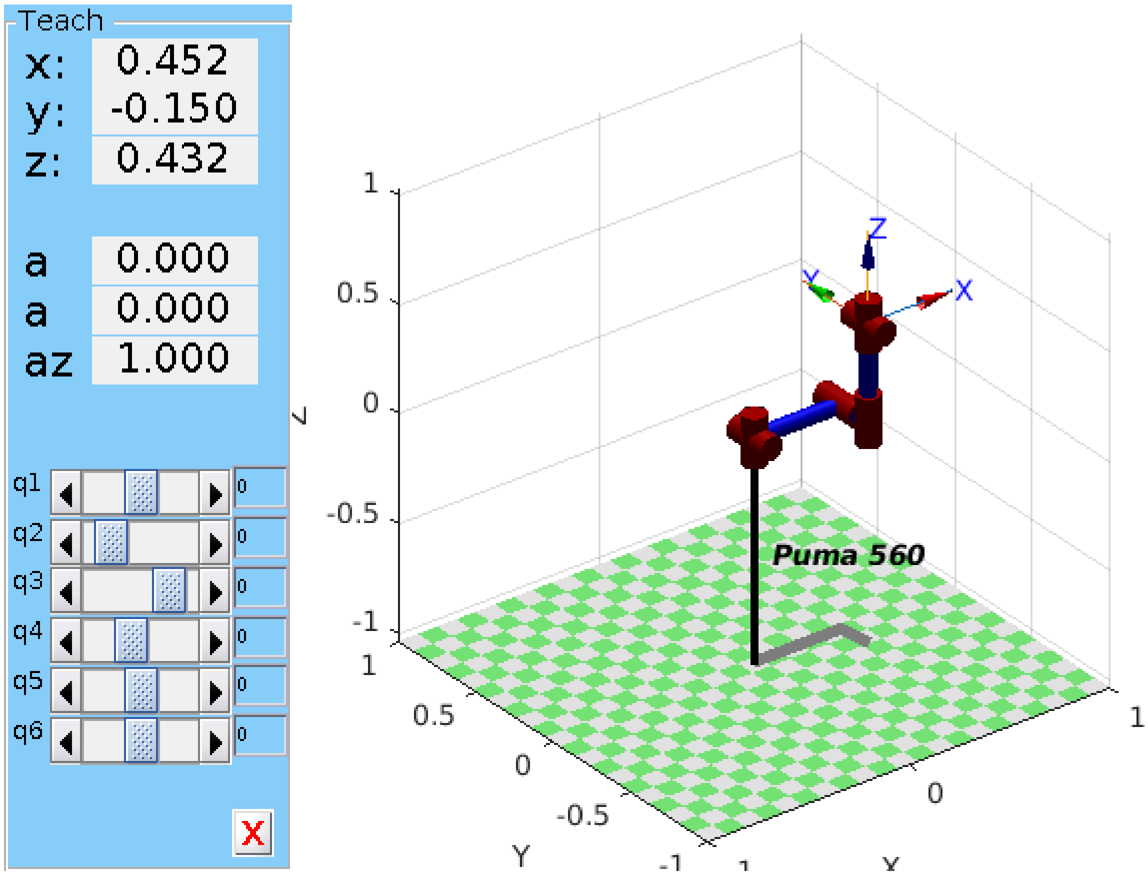



```
% view([-37.5 30])
```

Play with the teach

It is a kind of Joystick

```
view([-37.5 30])
p560.teach('approach')
```



Moving the Robot

```
clear all
close all
mdl_puma560
```

Declare a joint motion by adding rows

```
Q=zeros(100,6); % at the moment no motion
```

See the Joint 1 limits

```
q1_limits=p560.links(1, 1).qlim
```

```
q1_limits = 1×2
   -2.7925    2.7925
```

Build the joint's motion. Firts only Joint #1

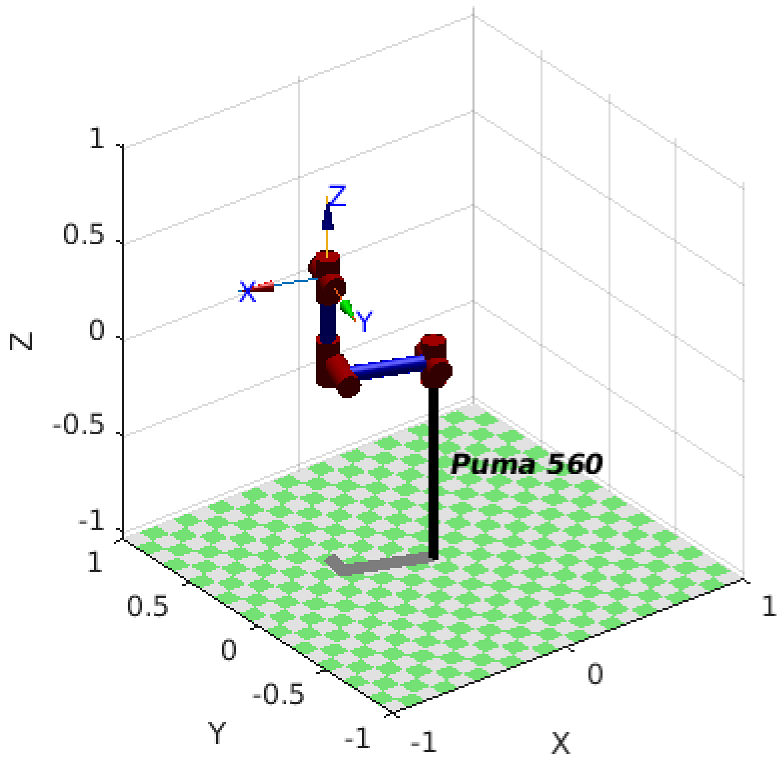
```
q1=linspace(q1_limits(1),q1_limits(2),100)';
Q=[q1 Q(:,2:6)]
```

```
Q = 100×6
   -2.7925         0         0         0         0         0
   -2.7361         0         0         0         0         0
   -2.6797         0         0         0         0         0
   -2.6233         0         0         0         0         0
   -2.5669         0         0         0         0         0
```

```
-2.5105         0         0         0         0         0
-2.4540         0         0         0         0         0
-2.3976         0         0         0         0         0
-2.3412         0         0         0         0         0
-2.2848         0         0         0         0         0
   ⋮
```

Plotting

```
p560.plot(Q)
```



Play with the plot options

Moving two joints. See above

```
q2_limits=p560.links(1, 2).qlim
```

```
q2_limits = 1×2
   -0.7854    3.9270
```

```
q2=linspace(q2_limits(1),q2_limits(2),100)';
Q12=[q1 q2 Q(:,3:6)];
```

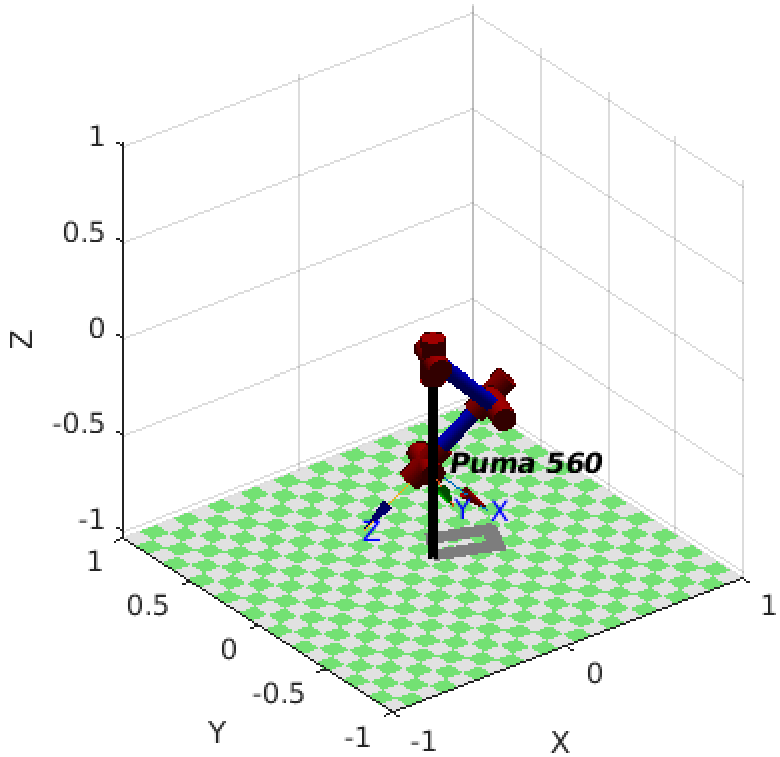
Options: Add a trail to see the trajectory, display the join axis, make biger or smaller the robot

Visit the RTB manual.pdf at:

- https://atenea.upc.edu/pluginfile.php/3871049/mod_resource/content/3/robot.pdf or

- https://petercorke.com/toolboxes/robotics-toolbox/

```
p560.plot(Q12,'trail','--','jaxes','zoom',2) %% Play outside the mlx file to see it: co
```



Play with other options to get familiar with. You must! becouse all along the course it will be necesary

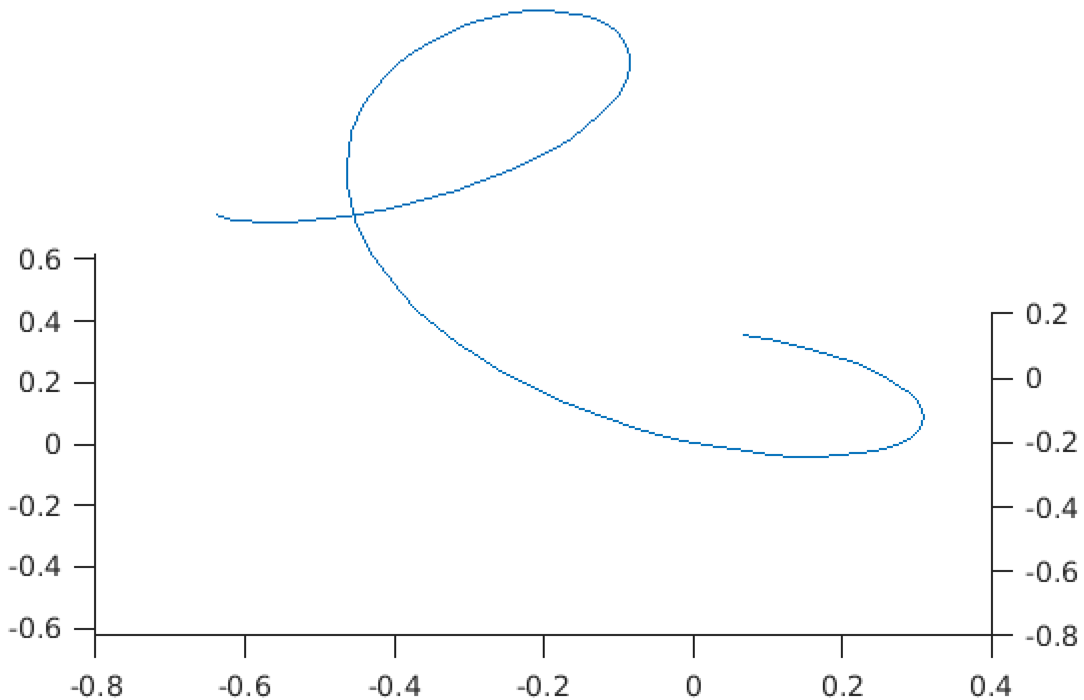
Recovering End efector position

Use function 'fkine' for recovering the finger tips of the robot

```
T=p560.fkine(Q12); % Forward Kinematic to be explained. Given Theta's (q's) obtain the
ft=[T.t] % to gert only the position
```

```
ft = 3×100
   -0.6386   -0.6335   -0.6251   -0.6135   -0.5990   -0.5817   -0.5618   -0.5397 ···
   -0.0728   -0.1086   -0.1436   -0.1772   -0.2092   -0.2393   -0.2672   -0.2928
   -0.0144    0.0154    0.0451    0.0747    0.1042    0.1334    0.1623    0.1909
```

```
figure
plot3(ft(1,:),ft(2,:), ft(3,:))
view(0,40)
```



Working area

```
clear all
close all
mdl_puma560
q2_limits=p560.links(1, 2).qlim
```

```
q2_limits = 1×2
   -0.7854    3.9270
```

```
q2=linspace(q2_limits(1),q2_limits(2),100)';
Q= [zeros(100,1) linspace(q2_limits(1),q2_limits(2),100)' zeros(100,4) ]
```

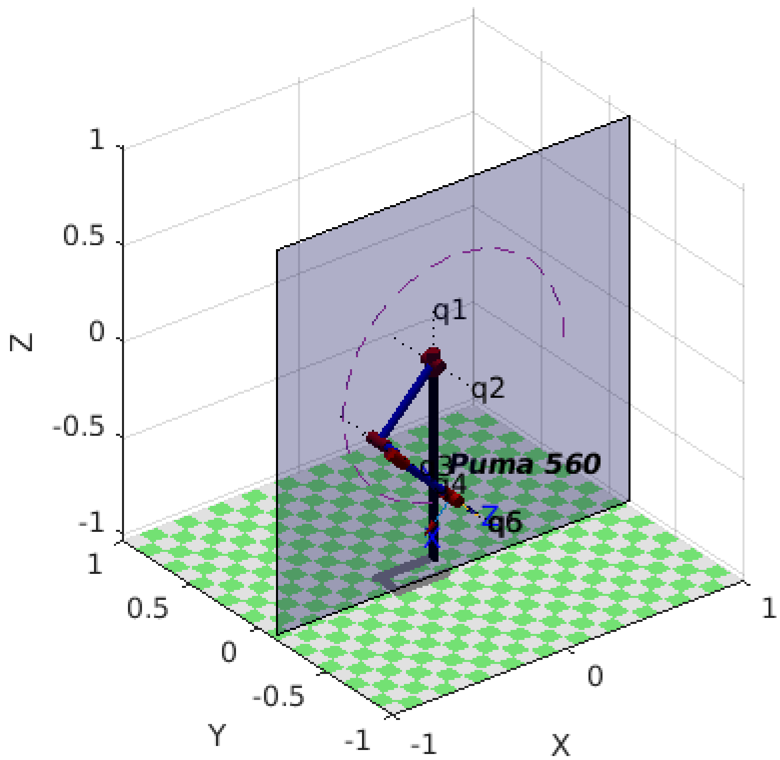
```
Q = 100×6
         0   -0.7854         0         0         0         0
         0   -0.7378         0         0         0         0
         0   -0.6902         0         0         0         0
         0   -0.6426         0         0         0         0
         0   -0.5950         0         0         0         0
         0   -0.5474         0         0         0         0
         0   -0.4998         0         0         0         0
         0   -0.4522         0         0         0         0
         0   -0.4046         0         0         0         0
         0   -0.3570         0         0         0         0
      ⋮
```

```
p560.plot(Q,'trail','--','jaxes','zoom',2)
T=p560.fkine(Q);
```

```
ft=[T.t]
```

```
ft = 3×100
    0.6250    0.6250    0.6235    0.6207    0.6164    0.6108    0.6037    0.5953 ···
   -0.1501   -0.1501   -0.1501   -0.1501   -0.1501   -0.1500   -0.1500   -0.1500
   -0.0144    0.0154    0.0451    0.0747    0.1042    0.1334    0.1623    0.1909
```

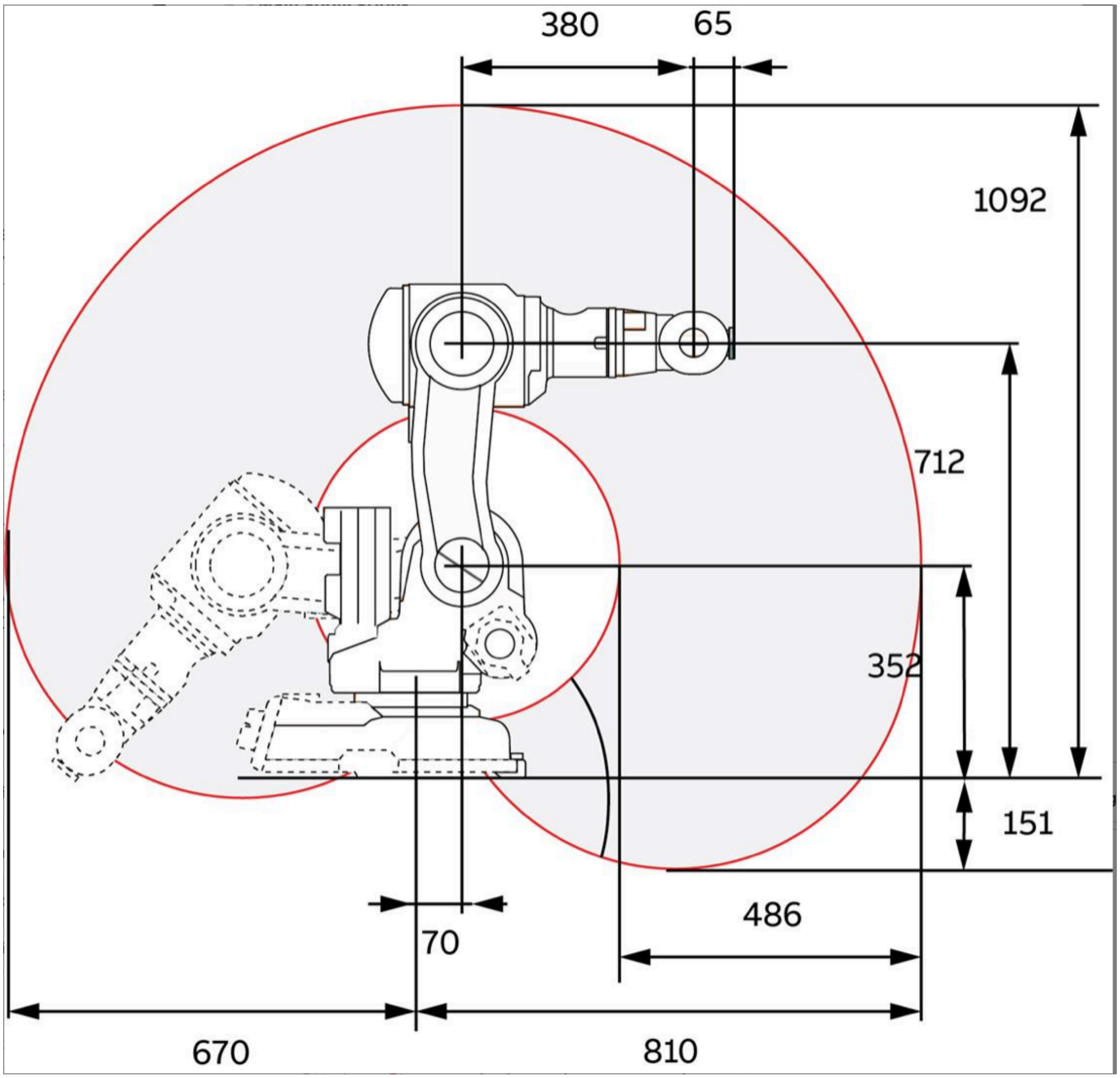
```
hold on
v = [-1 -0.1501 -1 ; 1 -0.1501 -1 ; 1 -0.1501 1; -1 -0.1501 1];
f = [1 2 3 4];
patch('Faces',f,'Vertices',v,'FaceColor','blue','FaceAlpha',.3)
```



IRB140 exercise

Make the same exercise for the irb140 manipulator and plot the working area as shown in the figure

Type of motion	Range of movement
Axis 1: Rotation motion	+180° to - 80°
Axis 2: Arm motion	+110° to -90°
Axis 3: Arm motion	+50° to -230°
Axis 4: Wrist motion	+200° to +200° Default +165 revolutions to -165 revolutions Max**)
Axis 5: Bend motion	+120° to -120°
Axis 6: Turn motion	+400° to -400° Default +163 revolutions to -163 revolutions Max**)



Invoque IRB140

```
clear
close all
```

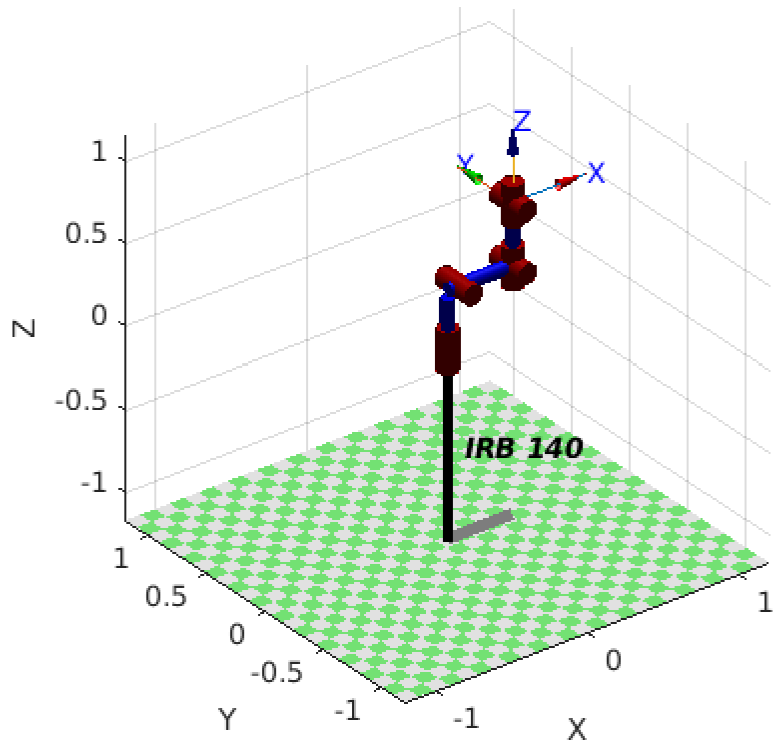
```
mdl_irb140
```

```
robot =

IRB 140 [ABB]:: 6 axis, RRRRRR, stdDH, slowRNE
+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|      0.352|       0.07|    -1.5708|          0|
|  2|         q2|          0|       0.36|          0|          0|
|  3|         q3|          0|          0|     1.5708|          0|
|  4|         q4|       0.38|          0|    -1.5708|          0|
|  5|         q5|          0|          0|     1.5708|          0|
|  6|         q6|          0|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+
```

Plot the IRB

```
irb140.plot(qz)
```



Workspace TODO.

- Q1.- Irb140 object has empty the field of q_limints. Use the given table. Remenbe the variables can be written. Translate it to radians.
- Q2. Do not confuse yourselft with 'qz'. It is just a robot configuration. Use 'qr' joint configuration as the home position. (q2 and q3 facing up)

- Q3. From that pose you can add and substract half range.
- Q4. I am going to give you the pseudo code for the outer right positions
- a) interpolate joint 2 (q2) from qr till (qr+half range), its limit.
- b) Then interpolate joint 3 (q3) from qr till (qr+half range), its limit.
- c) Build the Q (200x6) matrix of joints space
- d) Use 'ikine' function to recover {EE} position.You will get first and fourth quadrant.

The solution I am giving to you do not take into consideration the asimetry in

the ranges. But I hope it will inspire you.

Working area

```
clear all
close all

mdl_irb140
```

```
robot =

IRB 140 [ABB]:: 6 axis, RRRRRR, stdDH, slowRNE
+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|      0.352|       0.07|    -1.5708|          0|
|  2|         q2|          0|       0.36|          0|          0|
|  3|         q3|          0|          0|     1.5708|          0|
|  4|         q4|       0.38|          0|    -1.5708|          0|
|  5|         q5|          0|          0|     1.5708|          0|
|  6|         q6|          0|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+
```

```
limits = [-80 180; -90 110; -230 50]
```

```
limits = 3×2
   -80   180
   -90   110
  -230    50
```

```
limits = deg2rad(limits)
```

```
limits = 3×2
   -1.3963    3.1416
   -1.5708    1.9199
   -4.0143    0.8727
```

```
irb140.links(2).qlim = limits(2,:)
```

```
irb140 =

IRB 140 [ABB]:: 6 axis, RRRRRR, stdDH, slowRNE
+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
```

```
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|      0.352|       0.07|    -1.5708|          0|
|  2|         q2|          0|       0.36|          0|          0|
|  3|         q3|          0|          0|     1.5708|          0|
|  4|         q4|       0.38|          0|    -1.5708|          0|
|  5|         q5|          0|          0|     1.5708|          0|
|  6|         q6|          0|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+
```

```
irb140.links(3).qlim = limits(3,:)
```

```
irb140 = 

IRB 140 [ABB]:: 6 axis, RRRRRR, stdDH, slowRNE
+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|      0.352|       0.07|    -1.5708|          0|
|  2|         q2|          0|       0.36|          0|          0|
|  3|         q3|          0|          0|     1.5708|          0|
|  4|         q4|       0.38|          0|    -1.5708|          0|
|  5|         q5|          0|          0|     1.5708|          0|
|  6|         q6|          0|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+
```

```
position0 = [qr(1) qr(2)+limits(2,1) qr(3)+limits(3,1) qr(4:6)];
irb140.plot(position0)
view(0,0)

index = 200;
q1 = zeros(index,1) + qr(1);
q2 = linspace(qr(2)+limits(2,1),limits(2,2),index)';
q3 = linspace(qr(3)+limits(3,1),limits(3,2),index)';
q4_6 = zeros(index,3) + qr(4:6);
Q = [q1 q2 q3 q4_6]
```

```
Q = 200×6
         0   -3.1416   -2.4435         0    1.5708   -1.5708
         0   -3.1162   -2.4268         0    1.5708   -1.5708
         0   -3.0907   -2.4101         0    1.5708   -1.5708
         0   -3.0653   -2.3935         0    1.5708   -1.5708
         0   -3.0399   -2.3768         0    1.5708   -1.5708
         0   -3.0144   -2.3601         0    1.5708   -1.5708
         0   -2.9890   -2.3435         0    1.5708   -1.5708
         0   -2.9636   -2.3268         0    1.5708   -1.5708
         0   -2.9381   -2.3101         0    1.5708   -1.5708
         0   -2.9127   -2.2935         0    1.5708   -1.5708
     ⋮
```

```
irb140.plot(Q,'trail','--','jaxes','zoom',2)

T = irb140.fkine(Q); ft = [T.t]
```

```
ft = 3×200
```

```
  -0.0457   -0.0336   -0.0217   -0.0100    0.0015    0.0126    0.0234    0.0340 ···
   0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
   0.6431    0.6417    0.6398    0.6375    0.6346    0.6313    0.6275    0.6234
```

```
hold on
plot3(ft(1,:),ft(2,:), ft(3,:))
```