**Adrian Cristian Crisan**

https://drive.matlab.com/sharing/67e401c0-ccbc-48e9-9c17-19f694be4e96

# Milling and Welding Todo

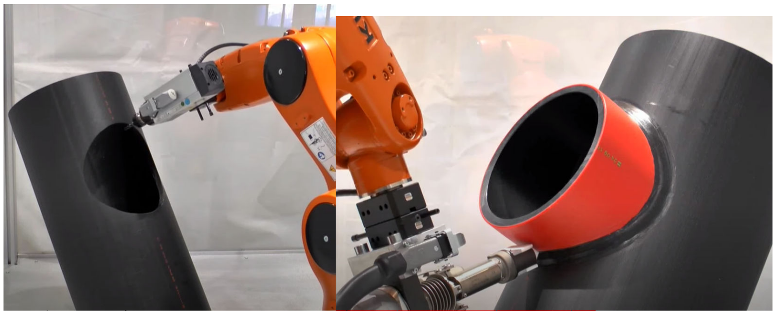
I have solved for you as an example the drilling task. Similar procedure ought to be done with welding task

**Table of Contents**

See the video: https://youtu.be/cVZWm9ORY30

As you can see in the video a Robot Arm perform three task. Only two tasks are shown:

1. Make a hole in a cylinder by drilling it. Observe that the tool mantain the same orientation during the drilling task.
2. Insertion of a smaller cylinder not recorder here.
3. Welding the two cylinder. Observe that the tool always form a 45º among the two cylinder axis



## Load the cylinder data

```
clear;
close all;
clf
load('F_V_cylinder.mat');
```

## Plot the robot to initial position

Pay attention how to move the robot base and add a tool

```
radius = 0.20;
```

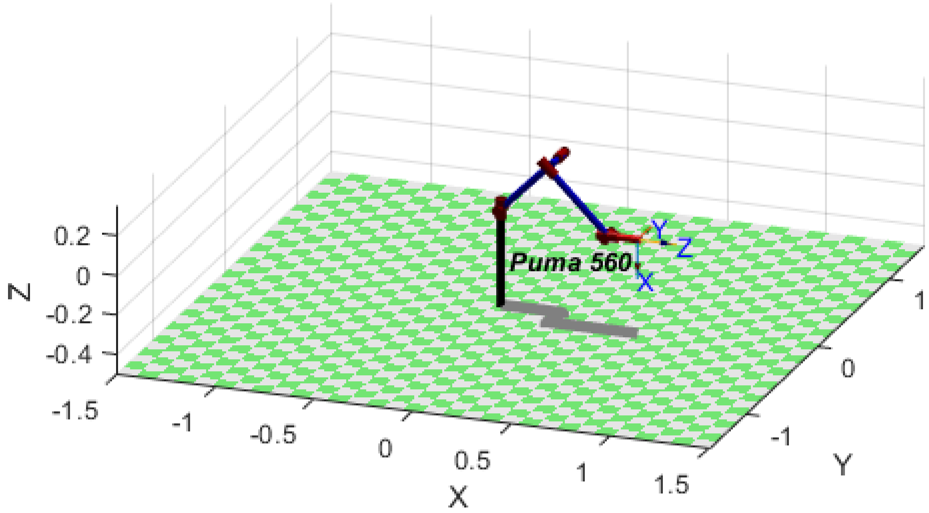
```
n = 200;
mdl_puma560
p560.base = transl(-0.1, 0, 0)
```

```
p560 = 

Puma 560 [Unimation]:: 6 axis, RRRRRR, stdDH, slowRNE
 - viscous friction; params of 8/95;
+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|     1.5708|          0|
|  2|         q2|          0|     0.4318|          0|          0|
|  3|         q3|    0.15005|     0.0203|    -1.5708|          0|
|  4|         q4|     0.4318|          0|     1.5708|          0|
|  5|         q5|          0|          0|    -1.5708|          0|
|  6|         q6|          0|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+
base:    t = (-0.1, 0, 0), RPY/xyz = (0, 0, 0) deg
```

```
p560.tool = transl(0,0,0.15)
```

```
p560 = 

Puma 560 [Unimation]:: 6 axis, RRRRRR, stdDH, slowRNE
 - viscous friction; params of 8/95;
+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|     1.5708|          0|
|  2|         q2|          0|     0.4318|          0|          0|
|  3|         q3|    0.15005|     0.0203|    -1.5708|          0|
|  4|         q4|     0.4318|          0|     1.5708|          0|
|  5|         q5|          0|          0|    -1.5708|          0|
|  6|         q6|          0|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+
base:    t = (-0.1, 0, 0), RPY/xyz = (0, 0, 0) deg
tool:    t = (0, 0, 0.15), RPY/xyz = (0, 0, 0) deg
```

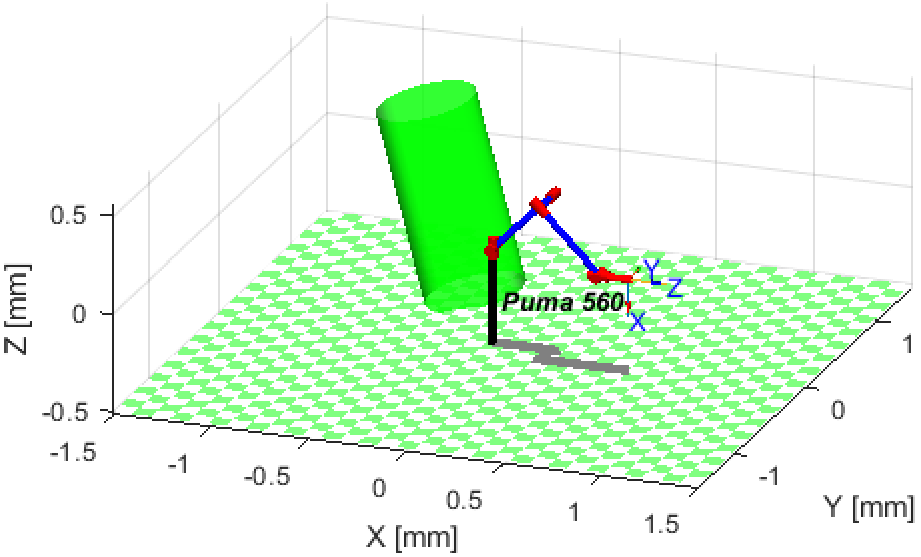
```
p560.plot(qn, 'zoom', 2.5, 'workspace', [-1.5 1.5 -1.5 1.5 -0.5 1], 'view', [20 20]);
axis equal
hold on
```



## Visualize the cylinder

This is the cylinder that we will drill

```
Cy_scale = 0.25;
CY_pose = transl([-0.3 0.3 -0.35]) * troty(-pi/6) * trotx(-pi/6);
V_cy_drill = CY_pose * [Cy_scale .* V_cy'; ones(1, length(V_cy))];
FVsPlot(F_cy,V_cy_drill(1:3,:)',[0 1 0])
```



## Visualize the other cylinder

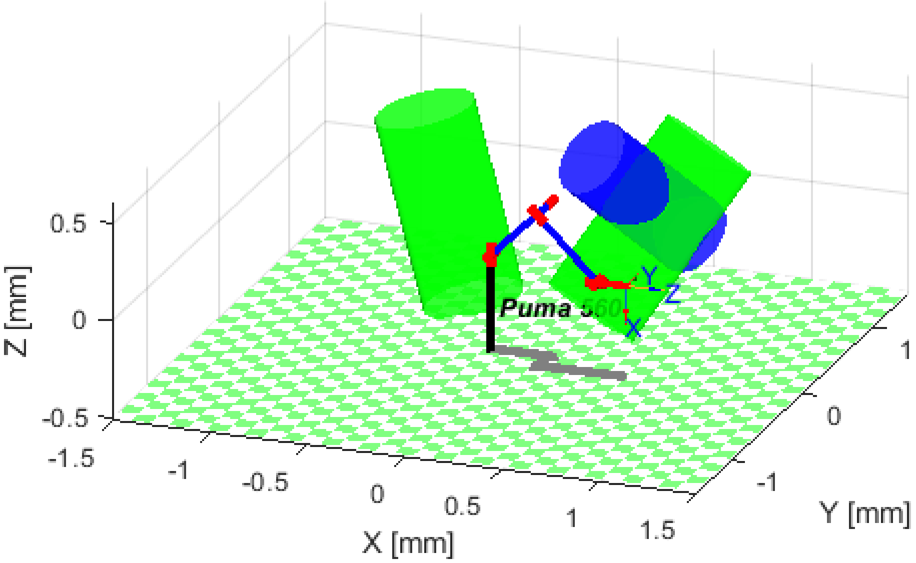
This are the cylinders that we will weld

The first one is the main cylinder

```
Cy_scale2 = 0.25;
CY_pose2 = transl([0.3 0.3 -0.35]) * troty(pi/6) * trotx(-pi/6);
V_cy_drill2 = CY_pose2 * [Cy_scale2 .* V_cy'; ones(1,length(V_cy))];
FVsPlot(F_cy, V_cy_drill2(1:3, :)', [0 1 0])
```

This second one is the welded cylinder

```
Cy_scale3 = 0.2;
CY_pose3 = CY_pose2 * transl(0,0,0.6) * trotx(pi/2) * troty(-pi/4) * transl(0,0,-0.25);

V_cy_drill3 = CY_pose3 * [Cy_scale3 .* V_cy'; ones(1,length(V_cy))];
FVsPlot(F_cy, V_cy_drill3(1:3,:)', [0 0 1])
```



## Draw drill task profile

Drill hole center 'D_h_c'

```
D_h_c = CY_pose * transl(0,0,0.6) * trotx(-pi/2) * troty(-pi/4) * transl(0,0,-0.25);
```

Drill poses

```
n=60
```

```
n = 60
```

```
for i=1:n
Drill_Pose(:,:,i)= D_h_c*trotz(2*pi*i/n)*transl(radius, 0,0);
end
```

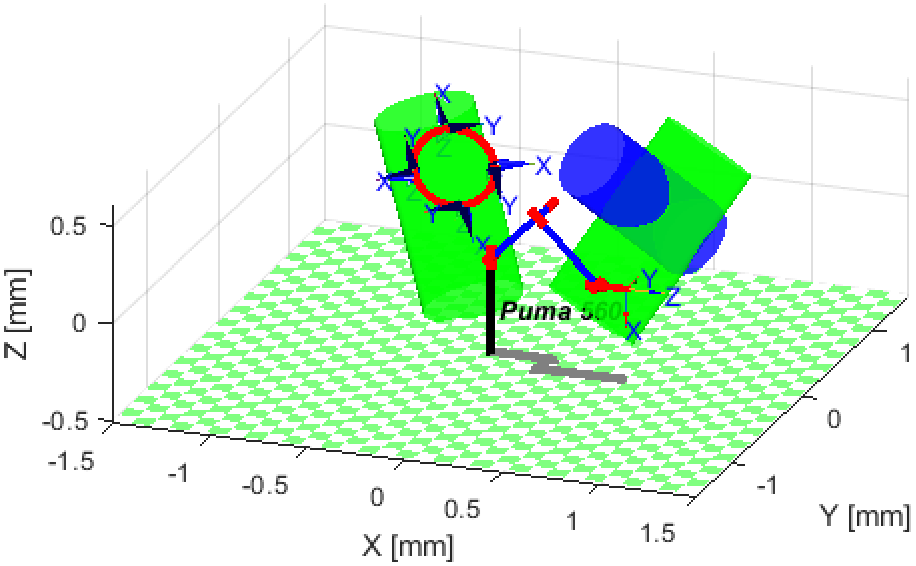
Plotting Drill poses. Notice 'z' axis of the poses

```
cir=transl(Drill_Pose)'
```

```
cir = 3×60
   -0.2849   -0.2785   -0.2740   -0.2715   -0.2709   -0.2723   -0.2757   -0.2809 ···
    0.5583    0.5459    0.5325    0.5181    0.5030    0.4872    0.4710    0.4545
    0.2587    0.2430    0.2276    0.2126    0.1981    0.1844    0.1716    0.1598
```

```
hold on
plot3(cir(1,:), cir(2,:), cir(3,:),'r','LineWidth',3);
```

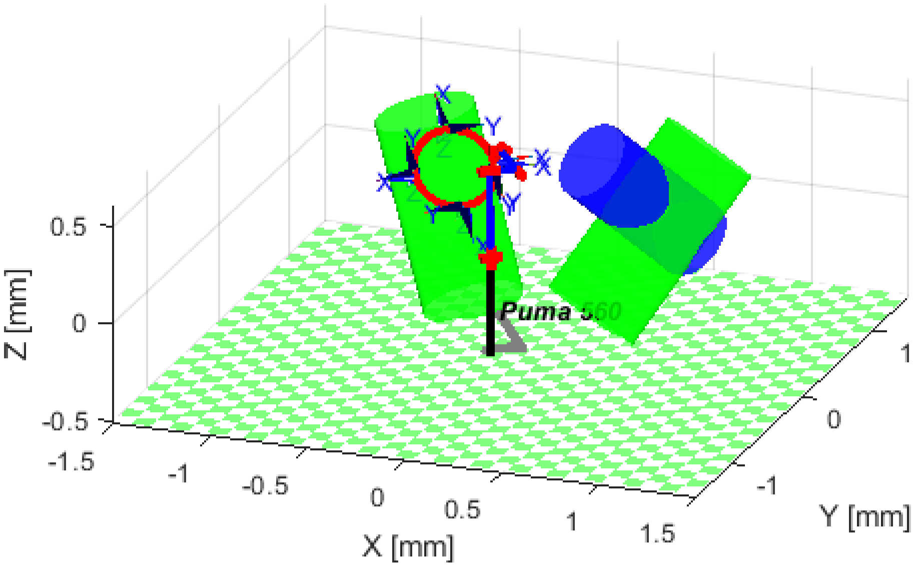
```
%axis([-1.5 1.5 -1.5 1.5 -0.5 1])
axis equal
trplot(Drill_Pose(:,:,1), 'length',0.2, 'arrow')
trplot(Drill_Pose(:,:,15), 'length',0.2, 'arrow')
trplot(Drill_Pose(:,:,30), 'length',0.2, 'arrow')
trplot(Drill_Pose(:,:,45), 'length',0.2, 'arrow')
```



## Recording the drilling task

```
Q = p560.ikine6s(Drill_Pose, 'run');
p560.plot(Q, 'view', [20 20], 'zoom', 1.5, 'workspace', [-1.5 1.5 -1.5 1.5 -0.5 1], ...
    'trail', '-', 'jaxes', 'zoom', 2, 'movie', 'Puma_drilling_task.mp4')
```

```
Animate: saving video --> Puma_drilling_task.mp4 with profile 'MPEG-4'
```



## Draw welding task profile

Welding hole center 'W_h_c'

```
W_h_c = CY_pose2 * transl(0,0,0.6) * trotx(pi/2) * troty(-pi/4) * transl(0,0,0.26)
```

```
W_h_c = 4×4
    0.7891    0.4330   -0.4356    0.4466
   -0.6124    0.5000   -0.6124    0.4408
   -0.0474    0.7500    0.6597    0.2715
         0         0         0    1.0000
```

Generating points

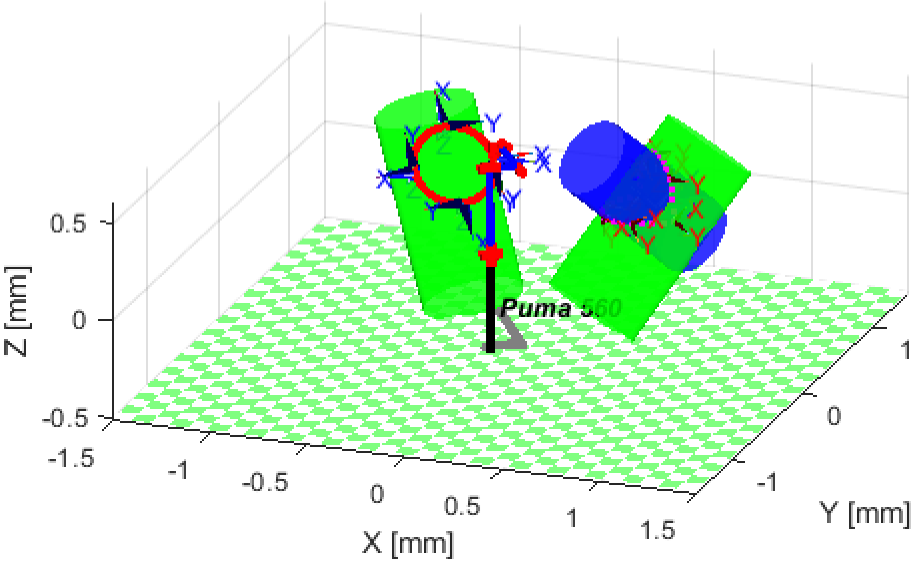
```
r=0.2;
t=0:pi/16:2*pi;
cp0=[r*cos(t);r*sin(t);abs(r*cos(t));ones(1,length(t))]
```

```
cp0 = 4×33
    0.2000    0.1962    0.1848    0.1663    0.1414    0.1111    0.0765    0.0390 ···
         0    0.0390    0.0765    0.1111    0.1414    0.1663    0.1848    0.1962
    0.2000    0.1962    0.1848    0.1663    0.1414    0.1111    0.0765    0.0390
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

Plotting Welding poses

```
% Translation of the welding
T0 = transl(0.5, 0.5, 0.2) * trotz(pi/4) * troty(-pi/4) * transl(0, 0, -0.1);
```

```
cp1 = T0 * cp0;

% Draws the welding
scatter3(cp1(1,:), cp1(2,:), cp1(3,:),'.', 'm', 'LineWidth', 2)

% Reference frame
trplot(T0, 'length', 0.2, 'arrow')

T1 = T0 * transl(0, 0.2, 0) * troty(pi) * trotx(pi/4);
trplot(T1, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')

T2 = T0 * transl(-0.141421, 0.141421, 0.141421) * troty(pi) * trotz(-pi/4) * trotx(pi/4);
trplot(T2, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')

T3 = T0 * transl(-0.2, 0, 0.2) * troty(pi) * trotz(-pi/2) * trotx(pi/4);
trplot(T3, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')

T4 = T0 * transl(-0.141421, -0.141421, 0.141421) * trotz(-pi/4) * trotx(-3*pi/4);
trplot(T4, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')

T5 = T0 * transl(0, -0.2, 0) * trotx(-3*pi/4);
trplot(T5, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')

T6 = T0 * transl(0.141421, -0.141421, 0.141421) * trotz(pi/4) * trotx(-3*pi/4);
trplot(T6, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')

T7 = T0 * transl(0.2, 0, 0.2) * troty(pi) * trotz(pi/2) * trotx(pi/4);
trplot(T7, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')

T8 = T0 * transl(0.141421, 0.141421, 0.141421) * troty(pi) * trotz(pi/4) * trotx(pi/4);
trplot(T8, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
```



```
Welding_Pose(:,:,1) = T1;
Welding_Pose(:,:,2) = T2;
Welding_Pose(:,:,3) = T3;
Welding_Pose(:,:,4) = T4;
Welding_Pose(:,:,5) = T5;
Welding_Pose(:,:,6) = T6;
Welding_Pose(:,:,7) = T7;
Welding_Pose(:,:,8) = T8;




Q = p560.ikine6s(Welding_Pose, 'run');
```

```
Warning: point not reachable
Warning: point not reachable
Warning: point not reachable
Warning: point not reachable
```

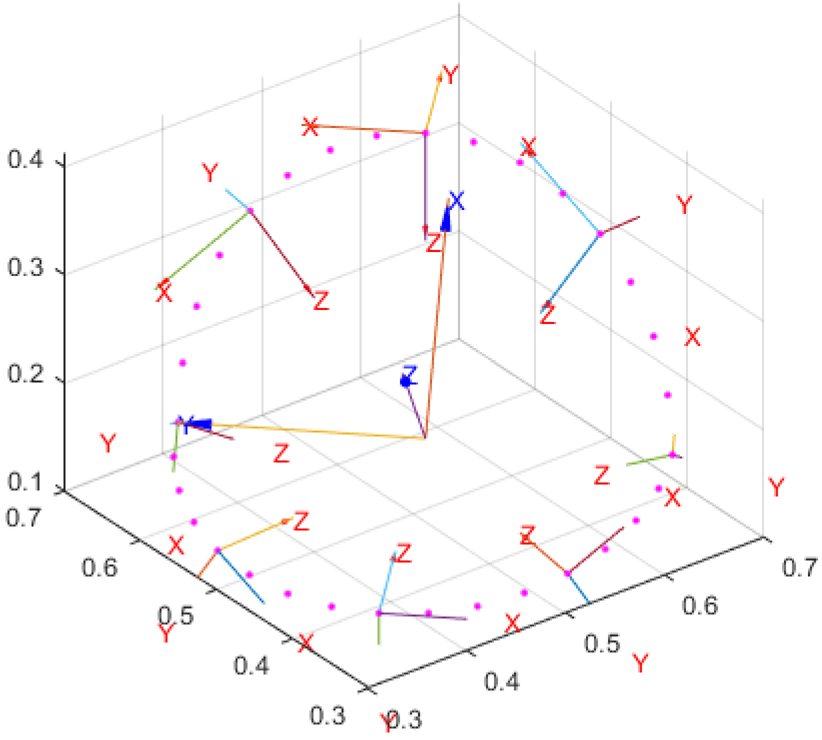
```
%p560.plot(Q,'view',[150 45], 'zoom',1.5,'workspace', [-1 0.5 -0.5 0.5 -1 1])
```

## Recording the welding task

```
% Q = p560.ikine6s(Welding_Pose, 'run');
% p560.plot( Q,'view',[150 45], 'zoom',1.5,'workspace', [-1 0.5 -0.5 0.5 -1 1],...
%               'trail','-','jaxes','zoom',2,'movie','Puma_welding_task.mp4')
```

## Only Welding points

```
figure
T0 = transl(0.5, 0.5, 0.2) * trotz(pi/4) * troty(-pi/4) * transl(0, 0, -0.1);
cp1 = T0 * cp0;
scatter3(cp1(1,:), cp1(2,:), cp1(3,:),'.', 'm', 'LineWidth', 2)

hold on

% Reference point
trplot(T0, 'length', 0.2, 'arrow')

trplot(T1, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
trplot(T2, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
trplot(T3, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
trplot(T4, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
trplot(T5, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
trplot(T6, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
trplot(T7, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
trplot(T8, 'length', r/2, 'arrow', 'width', 0.5, 'color','r')
```



## Functions

```
function T_b_a=FVsPlot(F,V,color)
patch('Faces',F,'Vertices',V,'FaceColor',color, ...
         'FaceAlpha',0.8,...
         'EdgeColor',       'none',        ...
         'FaceLighting',    'gouraud',     ...
         'AmbientStrength', 0.15);

% Add a camera light, and tone down the specular highlighting
camlight('headlight');
material('dull');

grid on
xlabel 'X [mm]'
ylabel 'Y [mm]'
zlabel 'Z [mm]'
axis equal
end
```