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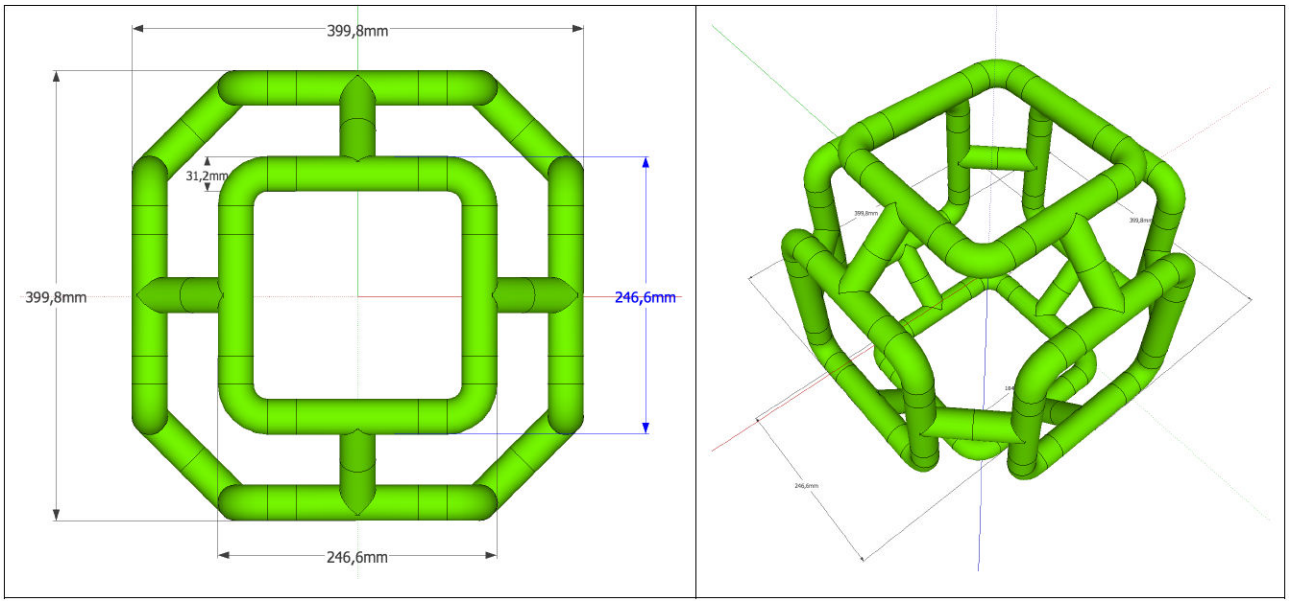
https://drive.matlab.com/sharing/84572005-d72b-448a-a1c6-f336f4be1588

Welding poses

A Unimation Puma 560 robot is used to weld a folded tubes frame as it is shown in the next figures.

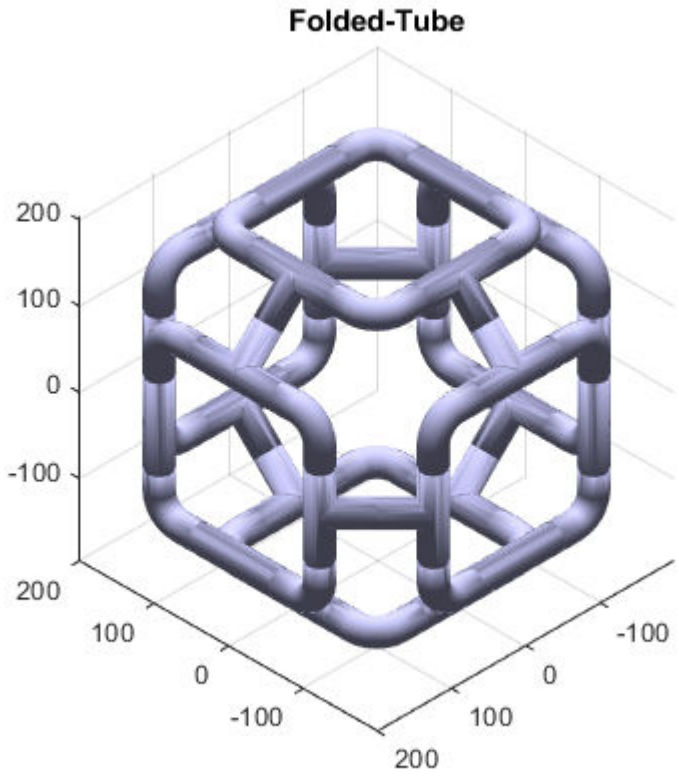


The task for the Puma 560 consists in welding the six folded squared tube among them with 32 points. The welding trajectory can be assumed to as two orthogonal and intersecting cylinders with radius = 15.6mm. The trajectory to be followed by the welder can be parameterized as follows:

$$p(t) = \begin{bmatrix} x(t) \\ y(t) \\ z(t) \end{bmatrix} = \begin{bmatrix} r\cos(t) \\ r\sin(t) \\ [\![r\cos(t)]\!] \end{bmatrix}; t \in [0 \quad 2\pi]$$

Read and plot the part

```
clear
[V,F, N,name]=stlRead('Folded_Tubes.stl');
clf
stlPlot(V,F,name)
axis equal
hold on
```



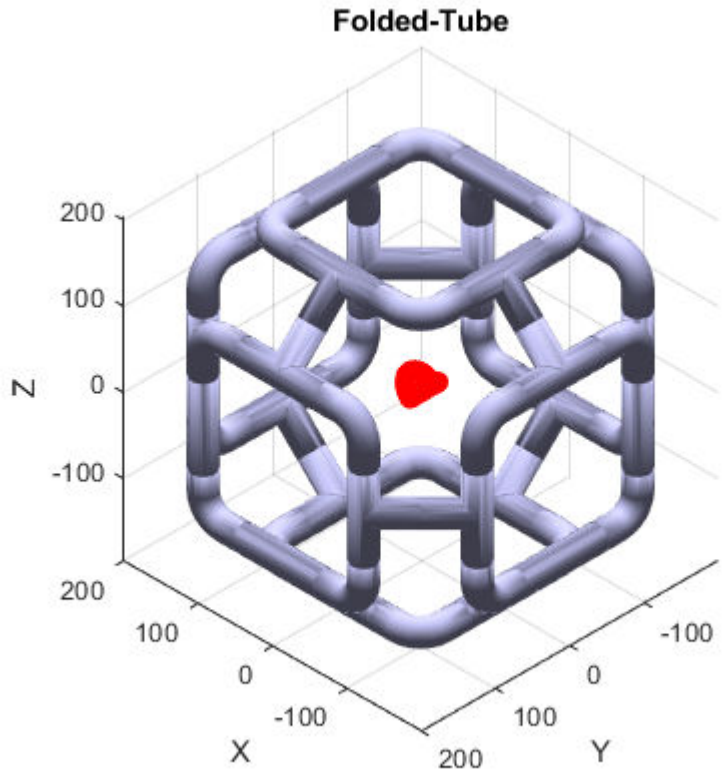
Setting up dimensions

```
r=15.6; % Tube radius
t=0:pi/16:2*pi; % Scan variable
cp0=[r*cos(t);r*sin(t);abs(r*cos(t));ones(1,length(t))]% dot height
```

```
cp0 = 4×33
   15.6000   15.3003   14.4125   12.9709   11.0309    8.6669    5.9699    3.0434 ···
         0    3.0434    5.9699    8.6669   11.0309   12.9709   14.4125   15.3003
   15.6000   15.3003   14.4125   12.9709   11.0309    8.6669    5.9699    3.0434
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

Plotting the welding points at origen

```
scatter3(cp0(1,:),cp0(2,:),cp0(3,:),'r','LineWidth',2)
xyzlabel% RTB
```



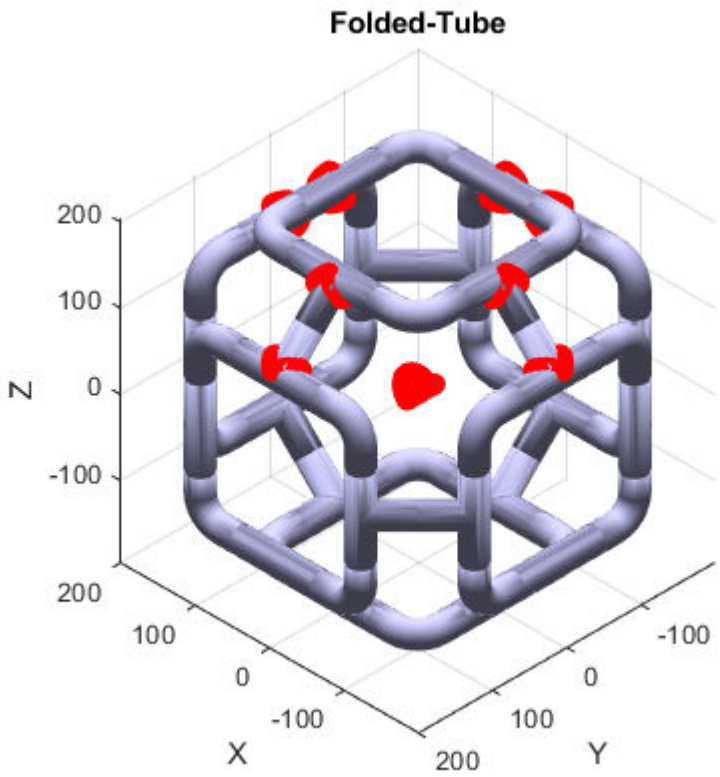
Obtain the weld point coordinates of two tubes

Get familiar with the following RTB functions:

help on: transl, trotx, troty, trotz

```
% First welding
TA_0 = transl(0.181887, 109.382, 188.585) * trotx(-135, 'deg');
cpA = TA_0 * cp0;

% Second welding
TB_0 = transl(0.181887, -106.906, 188.585) * trotx(135, 'deg');
TB_A = TB_0 * inv(TA_0);
cpB = TB_A * cpA;

% Third welding
TC_0 = transl(-107.962, 1.23804, 188.585) * trotz(90, 'deg') * trotx(-135, 'deg');
TC_A = TC_0 * inv(TA_0);
cpC = TC_A * cpA;

% Fourth welding
TD_0 = transl(108.326, 1.23, 188.585) * trotz(90, 'deg') * trotx(135, 'deg');
TD_A = TD_0 * inv(TA_0);
cpD = TD_A * cpA;

scatter3(cpA(1,:),cpA(2,:),cpA(3,:),'r','LineWidth', 2)
scatter3(cpB(1,:),cpB(2,:),cpB(3,:),'r','LineWidth', 2)
scatter3(cpC(1,:),cpC(2,:),cpC(3,:),'r','LineWidth', 2)
```

```
scatter3(cpD(1,:),cpD(2,:),cpD(3,:),'r','LineWidth', 2)

%% Second flor
% First welding
TE_0 = transl(0.181887, 185.715, 112.253) * trotx(45, 'deg');
cpE = TE_0 * cp0;

% Second welding
TF_0 = transl(0.181887, -183.238, 112.253) * trotx(-45, 'deg');
TF_E = TF_0 * inv(TE_0);
cpF = TF_E * cpE;

% Third welding
TG_0 = transl(-184.295, 1.23804, 112.253) * trotz(90, 'deg') * trotx(45, 'deg');
TG_E = TG_0 * inv(TE_0);
cpG = TG_E * cpE;

% Fourth welding
TH_0 = transl(184.658, 1.23, 112.253) * trotz(90, 'deg') * trotx(-45, 'deg');
TH_E = TH_0 * inv(TE_0);
cpH = TH_E * cpE;

scatter3(cpE(1,:),cpE(2,:),cpE(3,:),'r','LineWidth', 2)
scatter3(cpF(1,:),cpF(2,:),cpF(3,:),'r','LineWidth', 2)
scatter3(cpG(1,:),cpG(2,:),cpG(3,:),'r','LineWidth', 2)
scatter3(cpH(1,:),cpH(2,:),cpH(3,:),'r','LineWidth', 2)
xyzlabel% RTB
```



```
tube1 = [cpA, cpE]
```

```
tube1 = 4×66
   15.7819   15.4821   14.5944   13.1528   11.2128    8.8488    6.1517    3.2253 ···
  120.4129  118.0489  115.3519  112.4254  109.3820  106.3386  103.4121  100.7151
  177.5541  175.6141  174.1725  173.2847  172.9850  173.2847  174.1725  175.6141
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

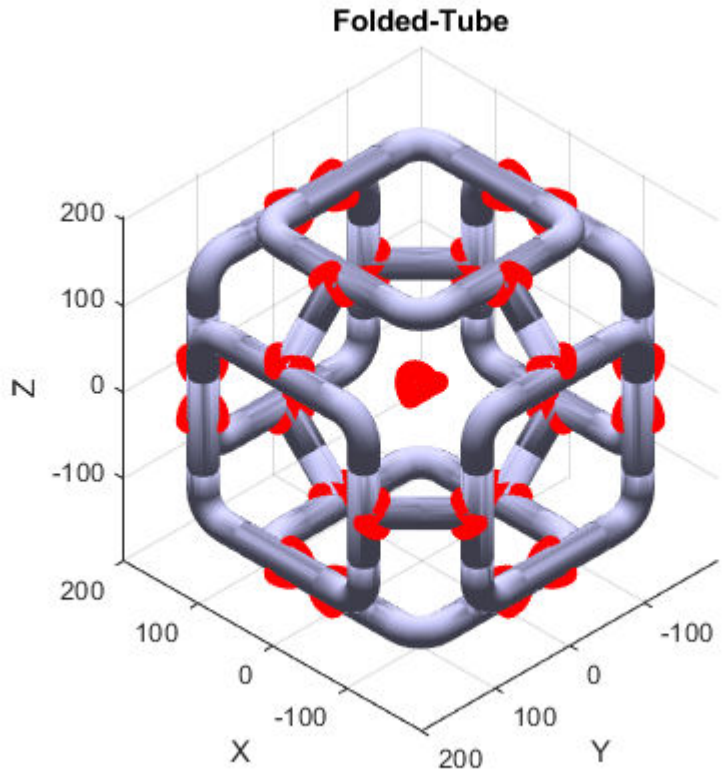
```
tube2 = [cpB, cpF]
```

```
tube2 = 4×66
   15.7819   15.4821   14.5944   13.1528   11.2128    8.8488    6.1517    3.2253 ···
 -117.9369 -119.8769 -121.3185 -122.2063 -122.5060 -122.2063 -121.3185 -119.8769
  177.5541  179.9181  182.6151  185.5416  188.5850  191.6284  194.5549  197.2519
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

All weldding points in a vector

Obtain a vector with weldding points of the six folded squared

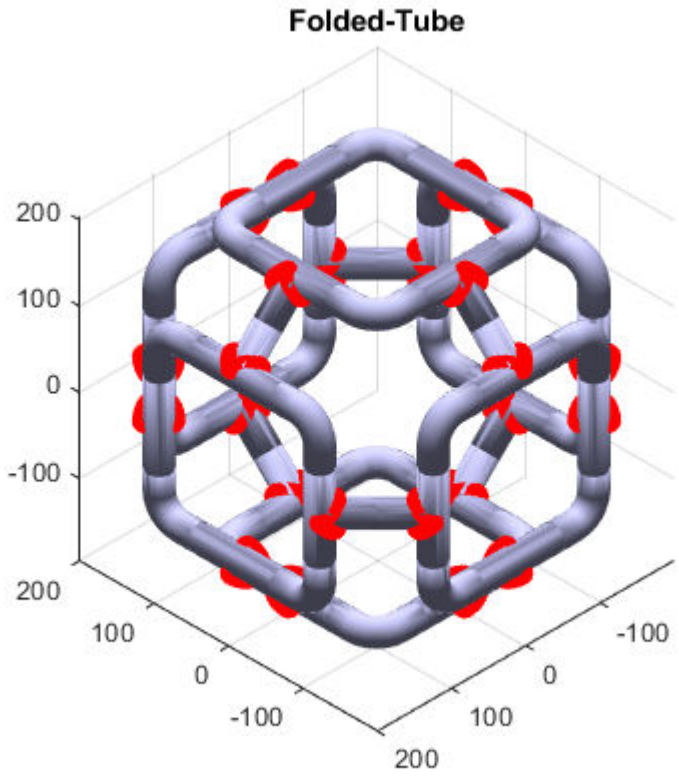
```
% Translate (I don't know why it is not symmetrical) and rotate the top (done above).
upper = [cpA, cpB, cpC, cpD, cpE, cpF, cpG, cpH];
T_lower = transl(0, 2.46804, 8.217) * trotx(180, 'deg');
lower = T_lower * upper;

scatter3(lower(1,:),lower(2,:),lower(3,:),'r','LineWidth', 2)

% Weld the x positive lateral part
TI_0 = transl(108.326, 185.715, 4.10875) * troty(90, 'deg') * trotx(45, 'deg');
cpI = TI_0 * cp0;

TJ_0 = transl(108.326, -183.238, 4.10875) * troty(90, 'deg') * trotx(-45, 'deg');
cpJ = TJ_0 * cp0;

TK_0 = transl(184.658, 109.382, 4.10875) * troty(90, 'deg') * trotx(-135, 'deg');
cpK = TK_0 * cp0;

TL_0 = transl(184.658, -106.906, 4.10875) * troty(90, 'deg') * trotx(135, 'deg');
cpL = TL_0 * cp0;

scatter3(cpI(1,:),cpI(2,:),cpI(3,:),'r','LineWidth', 2)
scatter3(cpJ(1,:),cpJ(2,:),cpJ(3,:),'r','LineWidth', 2)
scatter3(cpK(1,:),cpK(2,:),cpK(3,:),'r','LineWidth', 2)
scatter3(cpL(1,:),cpL(2,:),cpL(3,:),'r','LineWidth', 2)

% Weld the x negative lateral part doing a translation and a rotation

lateral = [cpI, cpJ, cpK, cpL];
T_lateral = transl(0.363, 0, 8.2175) * troty(180, 'deg');
lateral2 = T_lateral * lateral;

scatter3(lateral2(1,:),lateral2(2,:),lateral2(3,:),'r','LineWidth', 2)
hold off
```




```
[V,F, N,name]=stlRead('Folded_Tubes.stl');
clf
stlPlot(V,F,name)
axis equal
hold on

welddings = [upper, lower, lateral, lateral2]
```

```
welddings = 4×792
   15.7819   15.4821   14.5944   13.1528   11.2128    8.8488    6.1517    3.2253 ···
  120.4129  118.0489  115.3519  112.4254  109.3820  106.3386  103.4121  100.7151
  177.5541  175.6141  174.1725  173.2847  172.9850  173.2847  174.1725  175.6141
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

```
scatter3(welddings(1,:),welddings(2,:),welddings(3,:),'r','LineWidth', 2)
```


Folded-Tube
200
100
0
-100
200
100
0
-100
-100
0
100
200