



MATLAB Programming

STL File and Final Project



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Please install MeshLab software

▶ MeshLab

- <https://www.meshlab.net/#download>

MeshLab

the open source system for processing and editing 3D triangular meshes. It provides a set of tools for editing, cleaning, healing, inspecting, rendering, texturing and converting meshes. It offers features for processing raw data produced by 3D digitization tools/devices and for preparing models for 3D printing.



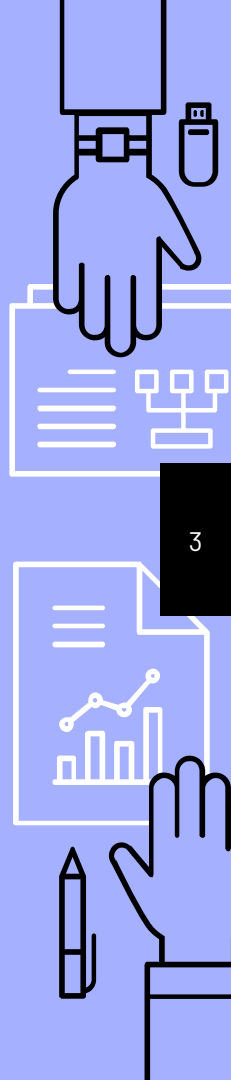


Contents

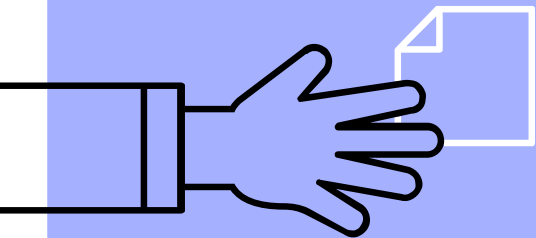
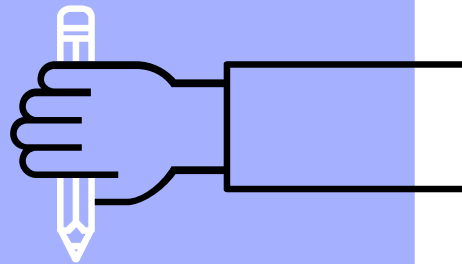
- ▶ Generate stereolithography(STL) file
- ▶ Instruction of final project

Please download the handout and materials from

http://cflu.lab.nycu.edu.tw/CFLu_course_matlabimage.html



產生STL模型檔



Faces & Vertices

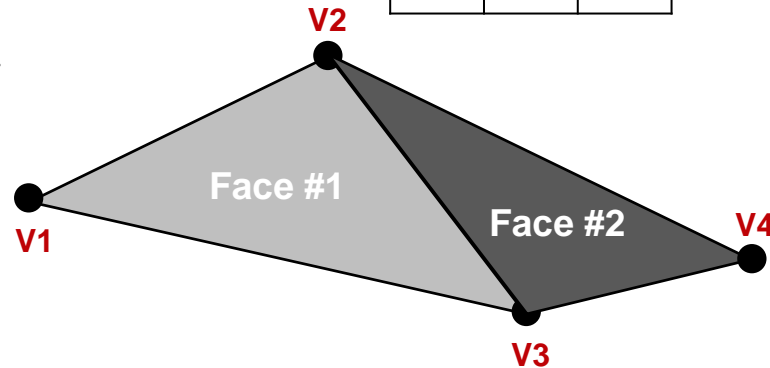
- ▶ `A=zeros(10,10,10);`
- ▶ `A(2:9,2:9,2:9)=1;`
- ▶ `[F,V] = isosurface(A,0);`

F (Faces)

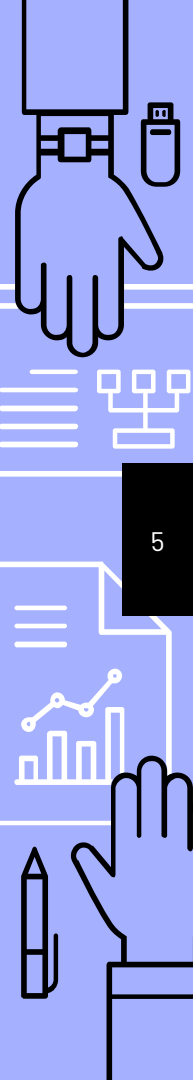
1	2	3
2	3	4

V (Vertices)

4	10	2
5	2	1
5	1	2
5	3	1

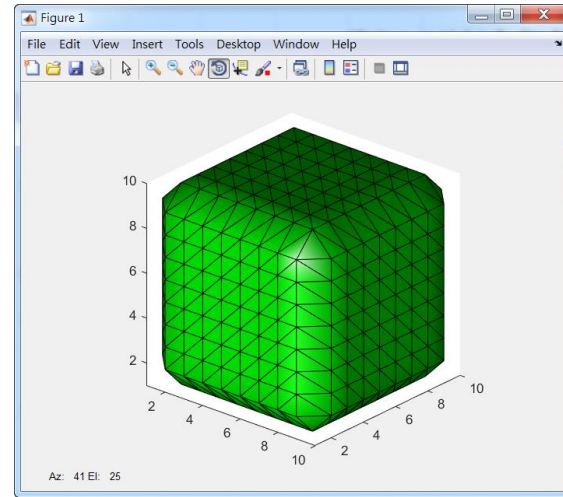


Each face is composed of 3 vertices.



Patch of a Cube

- ▶ `A=zeros(10,10,10);`
- ▶ `A(2:9,2:9,2:9)=1;`
- ▶ `[F,V] = isosurface(A,0);`
- ▶ `figure`
- ▶ `patch('Faces',F,'Vertices',V,'FaceColor',[0 1 0])`
- ▶ `lighting gouraud, camlight(0,0), view(30,30)`
- ▶ `axis equal`



STL format

▶ ASCII STL

- Start with **solid name**
- The file continues with any number of triangles, each represented as follows:

```
facet normal  $n_i$   $n_j$   $n_k$   
  outer loop  
    vertex  $v1_x$   $v1_y$   $v1_z$   
    vertex  $v2_x$   $v2_y$   $v2_z$   
    vertex  $v3_x$   $v3_y$   $v3_z$   
  endloop  
endfacet
```

- The file concludes with **endsolid name**

STL format

▶ ASCII STL

Open [MImaterials_L13\cube_ascii.stl](#) using NotePad (記事本)

```
cube.stl - 記事本
檔案(F) 編輯(E) 格式(O) 檢視(V) 說明(H)
solid CubeDemo
facet normal 5.7735026E-01 5.7735026E-01 5.7735026E-01
outer loop
vertex 2.0000000E+00 2.0000000E+00 1.0000000E+00
vertex 1.0000000E+00 2.0000000E+00 2.0000000E+00
vertex 2.0000000E+00 1.0000000E+00 2.0000000E+00
endloop
endfacet
facet normal 7.0710677E-01 -0.0000000E+00 7.0710677E-01
outer loop
vertex 2.0000000E+00 2.0000000E+00 1.0000000E+00
vertex 2.0000000E+00 3.0000000E+00 1.0000000E+00
vertex 1.0000000E+00 2.0000000E+00 2.0000000E+00
endloop
endfacet
facet normal 7.0710677E-01 -0.0000000E+00 7.0710677E-01
outer loop
vertex 2.0000000E+00 2.0000000E+00 1.0000000E+00
vertex 2.0000000E+00 3.0000000E+00 1.0000000E+00
vertex 1.0000000E+00 2.0000000E+00 2.0000000E+00
endloop
endfacet
endsolid CubeDemo
```

```
endfacet
facet normal -5.7735026E-01 -5.7735026E-01 -5.7735026E-01
outer loop
vertex 1.0000000E+01 9.0000000E+00 9.0000000E+00
vertex 9.0000000E+00 9.0000000E+00 1.0000000E+01
vertex 9.0000000E+00 1.0000000E+01 9.0000000E+00
endloop
endfacet
endsolid CubeDemo
```

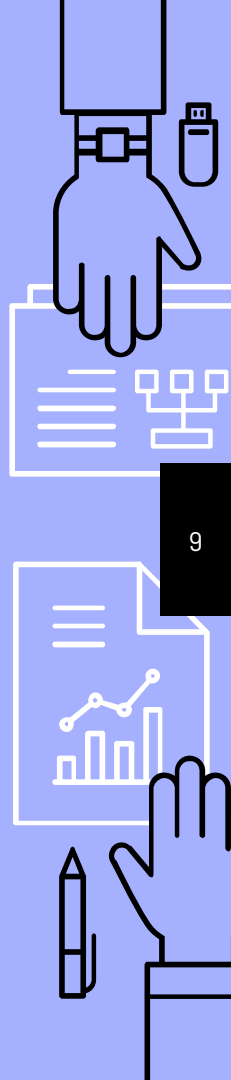

STL format

- ▶ Binary STL
 - Each triangle is described by twelve 32-bit floating-point numbers

```
UINT8[80] - Header
UINT32 - Number of triangles

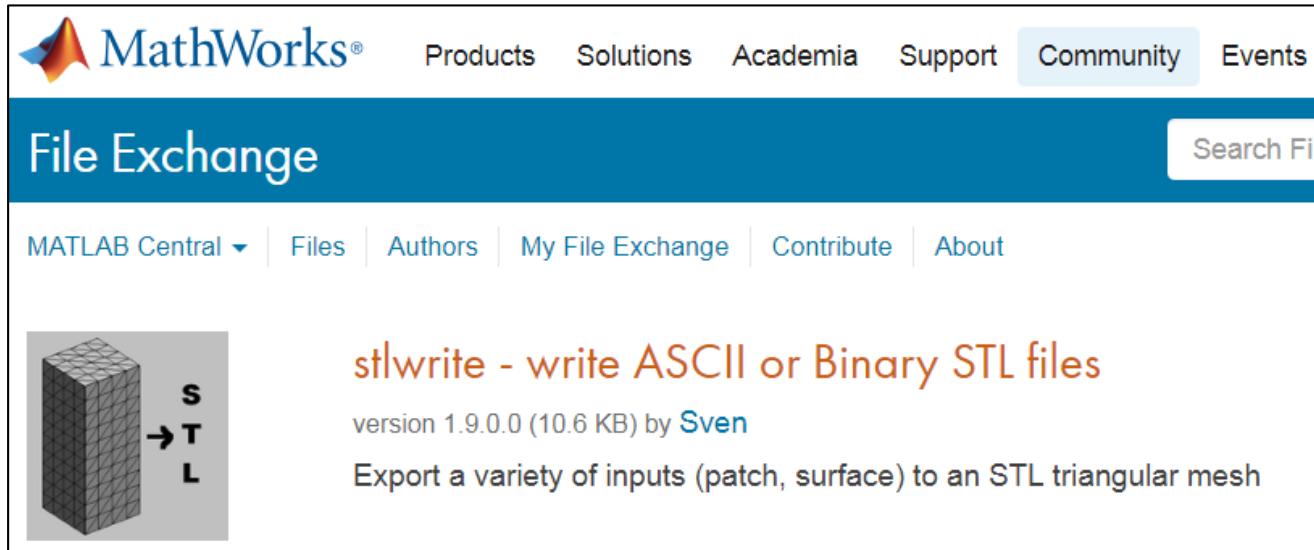
foreach triangle
REAL32[3] - Normal vector
REAL32[3] - Vertex 1
REAL32[3] - Vertex 2
REAL32[3] - Vertex 3
UINT16 - Attribute byte count
end
```

Binary STL has a smaller file size.



Export STL

- ▶ **stlwrite** function (released by Sven Holcombe)



The screenshot shows the MathWorks File Exchange page for the `stlwrite` function. The page header includes the MathWorks logo and navigation links for Products, Solutions, Academia, Support, Community, and Events. The main heading is "File Exchange" with a search bar. Below the heading, there are navigation links for MATLAB Central, Files, Authors, My File Exchange, Contribute, and About. The main content area features a 3D grid icon with "S", "T", and "L" labels, the title "stlwrite - write ASCII or Binary STL files", the version "version 1.9.0.0 (10.6 KB) by Sven", and the description "Export a variety of inputs (patch, surface) to an STL triangular mesh".

<https://www.mathworks.com/matlabcentral/fileexchange/20922-stlwrite-write-ascii-or-binary-stl-files>

Export STL

- ▶ **stlwrite** function (released by Sven Holcombe)

```
stlwrite('FILENAME',faces,vertices,'MODE','ascii','TITLE','NAME')
```

```
stlwrite('FILENAME',faces,vertices,'MODE','binary','TITLE','NAME')
```

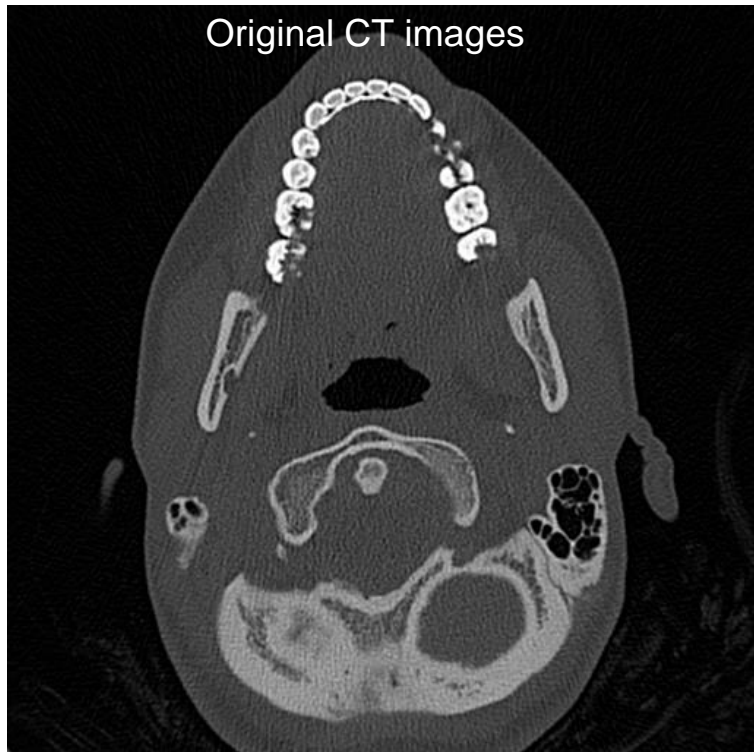
Examples:

```
stlwrite('cube_ascii.stl',F,V,'mode','ascii','title','CubeDemo')
```

```
stlwrite('cube_binary.stl',F,V,'mode','binary','title','CubeDemo')
```

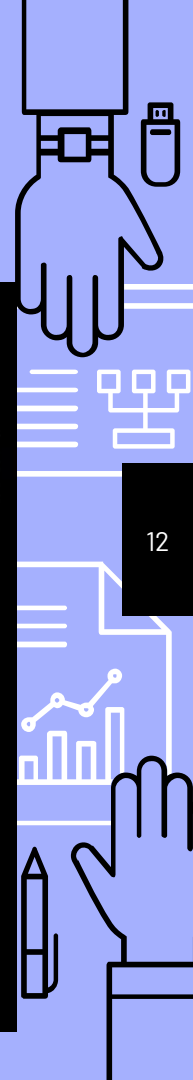
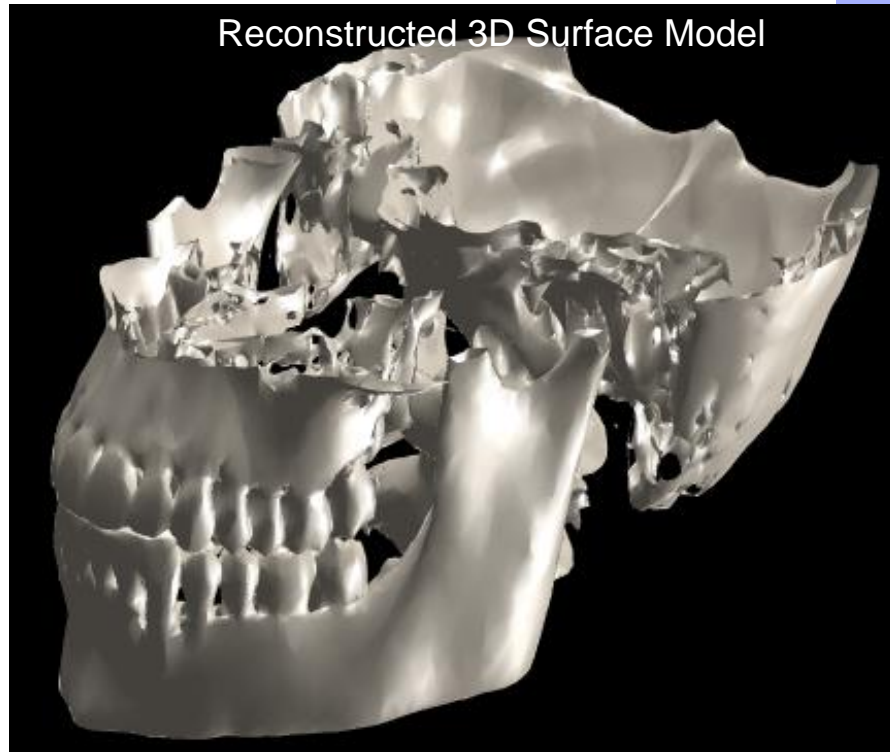
Dental CT Images

Original CT images



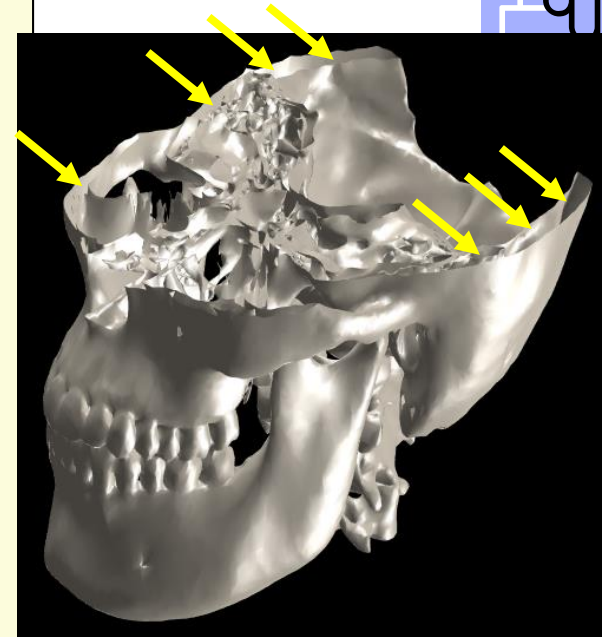
What we had last week....

Reconstructed 3D Surface Model



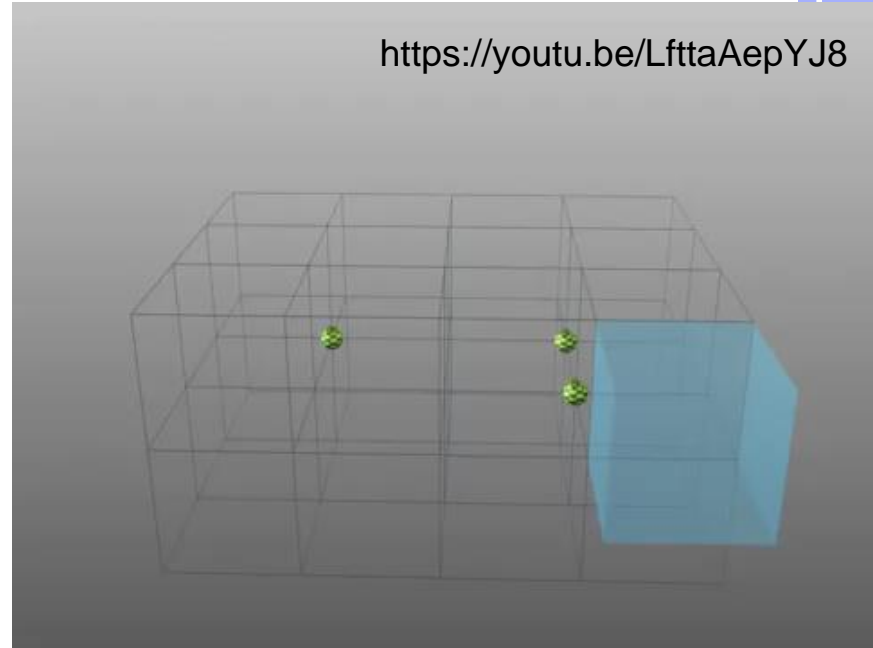
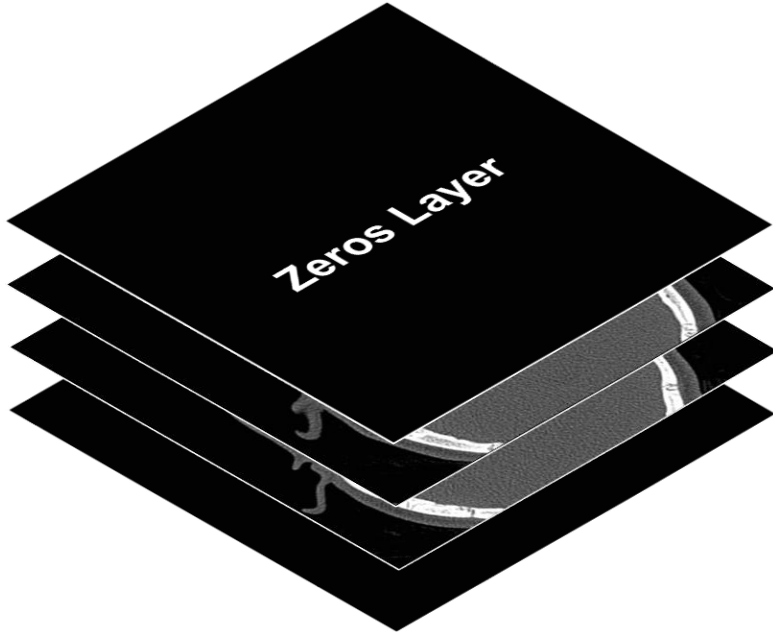
Dental Surface Model

```
7 %% perform isosurface and smoothing
8 img2=smooth3(img,'box',[3 3 3]);
9           Please select an appropriate threshold value.
10 [F,V] = isosurface(img3,1300);
11 [F,V] = reducepatch(F,V,0.1);
12 V=meshsmooth(F,V); % apply mesh smoothing
13
14 figure('color',[0 0 0])
15 patch('Faces',F,'Vertices',V,'FaceColor',[0.89 0.85 0.79],...
16       'Edgecolor','none')
17 lighting gouraud, camlight(43,25),camlight(180,0)
18 view(50,31)
19 axis equal, axis off
20 set(gca,'zdir','reverse')
```



Close up the Mesh

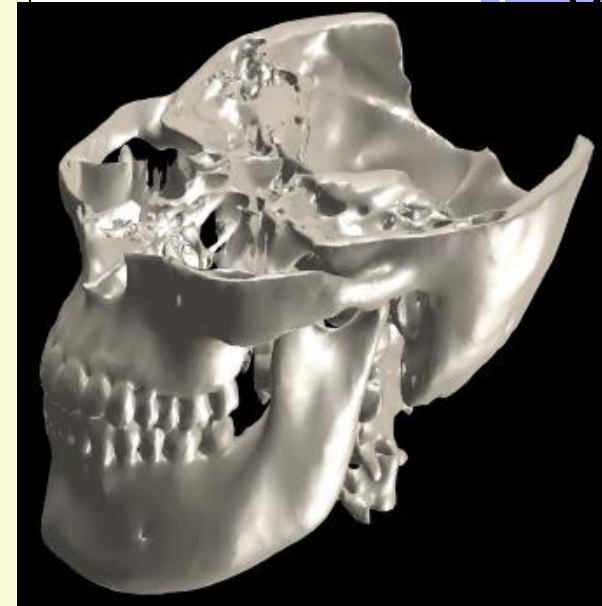
- ▶ Creating zero layers in the first and last slices.



Dental STL Model

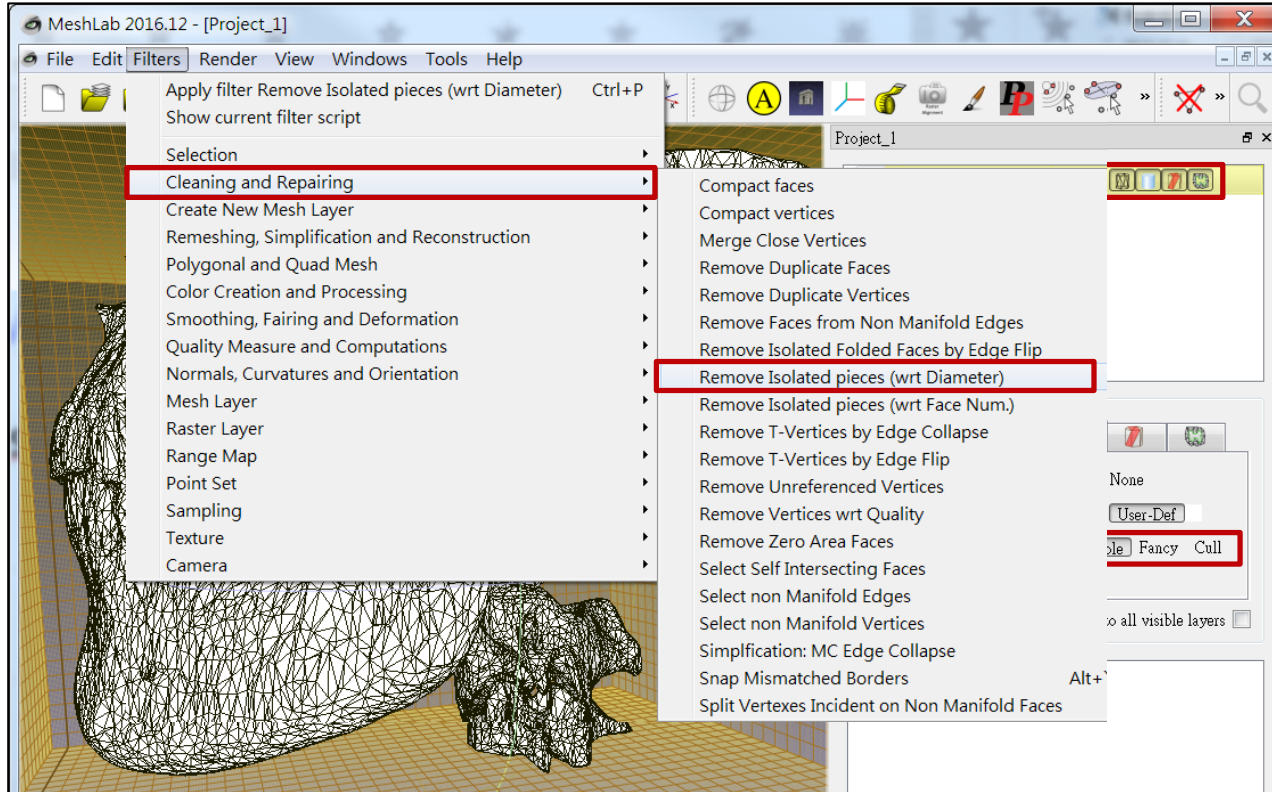
```
7 %% perform isosurface and smoothing
8 img2=smooth3(img,'box',[3 3 3]);
9
10 %%% Creating zero layers in the first and last slices
11 img3=zeros(size(img2,1),size(img2,2),size(img2,3)+2);
12 img3(:,:,2:end-1)=img2;
13 %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
14
15 [F,V] = isosurface(img3,1300);
16 [F,V] = reducepatch(F,V,0.1);
17 V=meshsmooth(F,V); % apply mesh smoothing
18
19 figure('color',[0 0 0])
20 patch('Faces',F,'Vertices',V,'FaceColor',[0.89 0.85 0.79],...
21      'Edgecolor','none')
22 lighting gouraud, camlight(43,25),camlight(180,0)
23 view(50,31)
24 axis equal, axis off
25 set(gca,'zdir','reverse')
26
27 %% export STL file
28 stlwrite('DentalCT_binary.stl',F,V,'mode','binary','title','Dental_CT')
```

M\materials_L13\Dental_STL.m

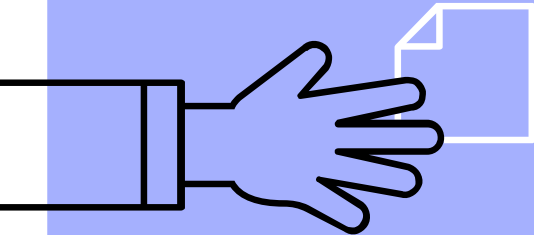
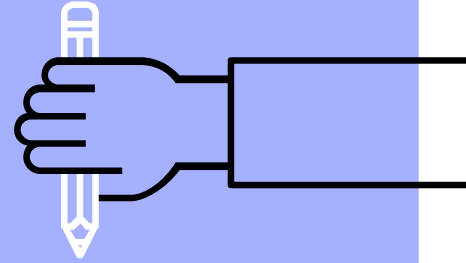




STL Model Clean & Repair



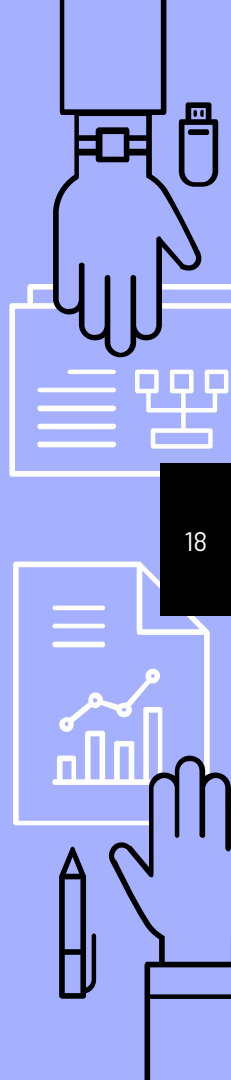
Instruction of Final Project



Syllabus – 3D Rendering & Printing

Week	Topic
11	Graphic structure - curve and image display
12	3D object rendering - surface and volume rendering
13 (12/8)	Introduction of 3D printing and STL file output
14 (12/15) ~ 15 (12/22)	1. Operation of Slicer (G-code file) and 3D printer (self learning) 2. 3D printing hands-on at NYCUCU Maker Space 3. Video recording (10 min) Please provide photos of 3D printing at MakerSpace, explanation of MATLAB codes, product showcase, problem/solution & discussion, and work assignment. All the required files of final report should be uploaded to E3 <u>before 12/28</u>
16 (12/29)	Final discussion at classroom in person (Please bring your headphone!)

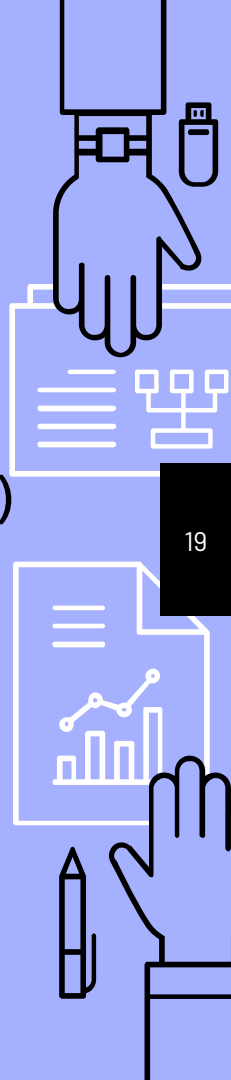
You may record the team report using Google Meet or screen recorder software.





Slicer and 3D Printer

- ▶ **Creality Slicer**
 - <https://former.creality.com/download>
- ▶ **Operation of Slicer and 3D Printer (self-learning materials)**
 - **Video:** <https://youtu.be/xv0vckeYrKg>
 - **Handout:** http://cflu.lab.nycu.edu.tw/Introduction_Slicer_Printer_CF.pdf



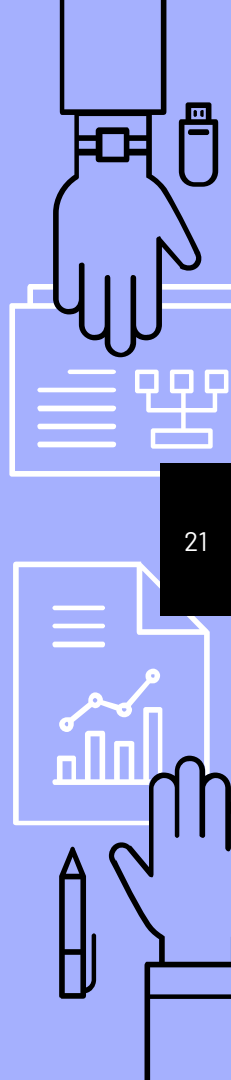
Final Report Files

- ▶ Final report video (10 min)
 - Photos of 3D printing at MakerSpace, explanation of MATLAB codes, product showcase, problem/solution & discussion, and work assignment.
- ▶ **Please upload all the required files of final report to E3 system before 12/28:**
 - 10-min video (*.mp4); Can be a YouTube or Google Drive link if the file size is too large.
 - PowerPoint file
 - Script file (*.m)
 - STL file



Work Assignment 小組分工範例

- ▶ MATLAB programming
(image processing, ROI, modeling)
- ▶ G-code file generation using Slicer software
- ▶ 3D printing (group photos at MakerSpace)
- ▶ PowerPoint slides and product presentation
- ▶ Video recording (should include all the group members)



陳姿樺

負責初始程式架構、

黃懷恩

找到真確模型與參數、

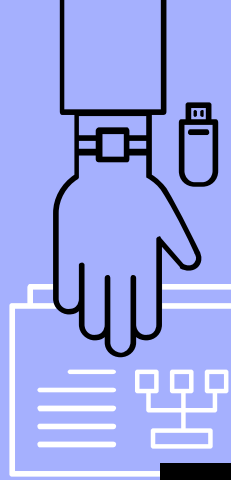
參數選擇

先



後

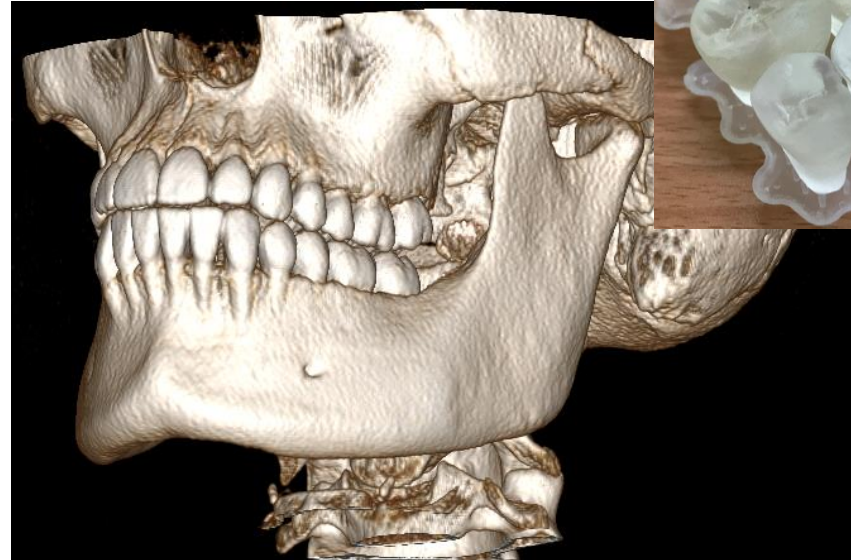
Isotropicvol 'mean'	Isotropicvol 'mean'	Isotropicvol 'mean'	Isotropicvol 'min'	Isotropicvol 'min'
Smooth3 [3 3 3]	Smooth3	Smooth3	Smooth3	Smooth3
isosurfac 1100				
meshsmo				
reducepat 0.1				



Dental CT

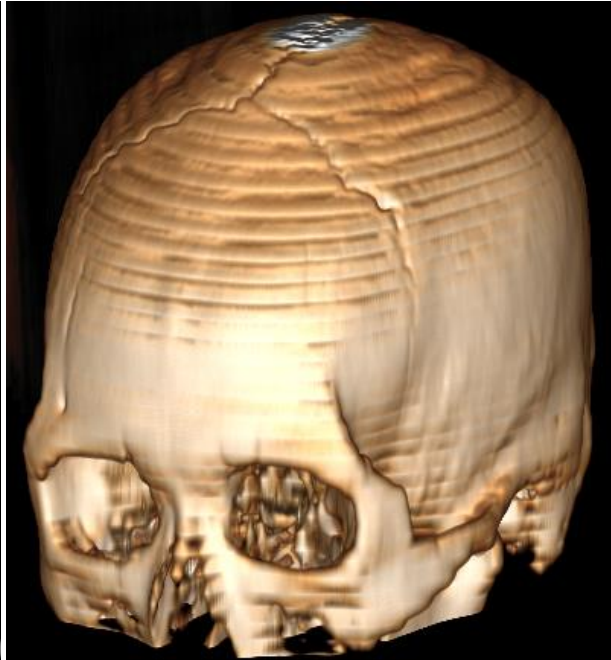
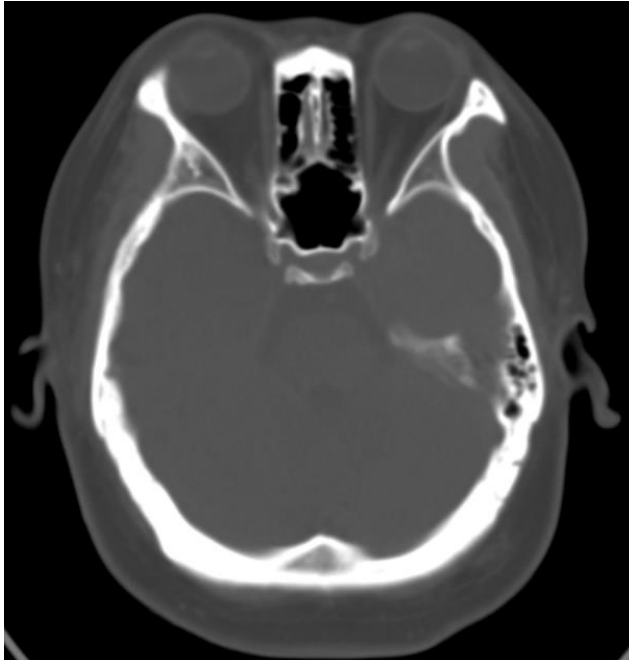


+ roipoly & proper thresholding



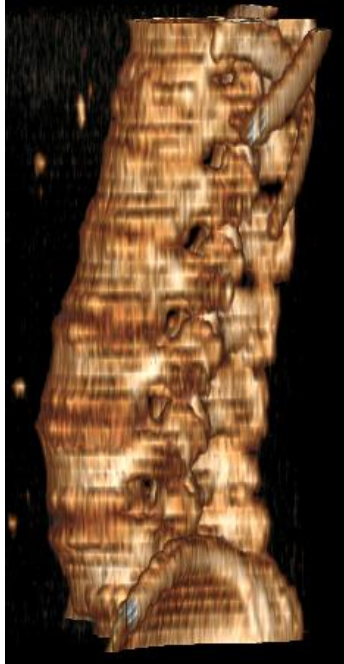
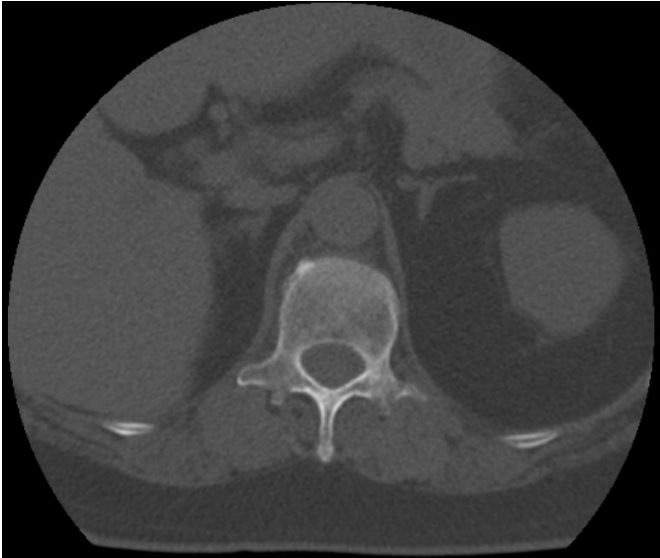
Skull CT

+ Image interpolation and smoothing



L-Spine CT

+ Image interpolation and smoothing



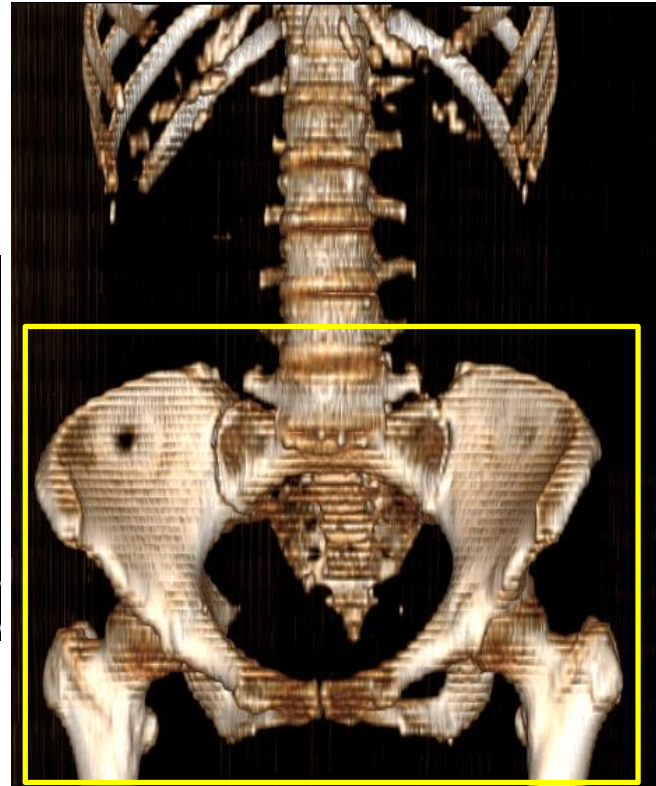
L-Spine CT

Photos shared by Team #2



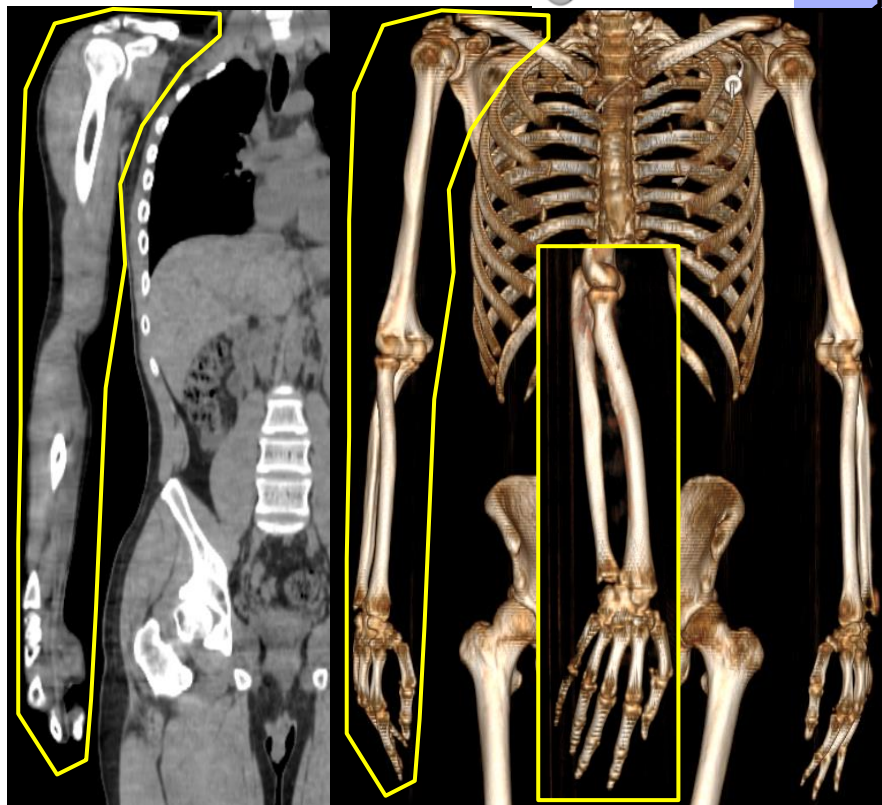
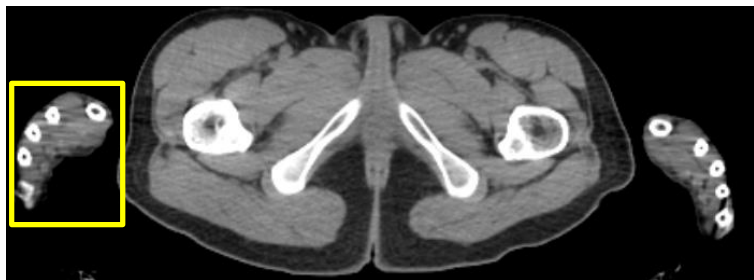
Pelvis CT

+ slice selection & proper thresholding



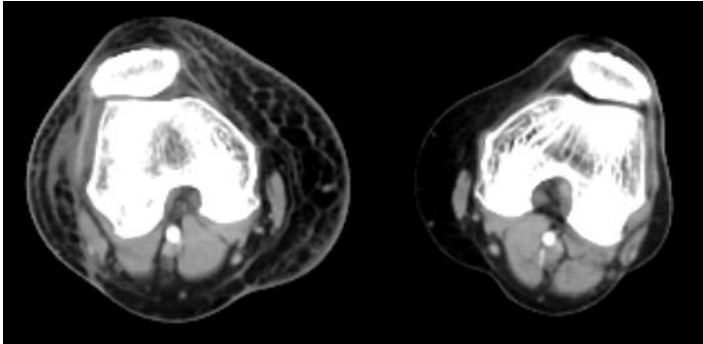
Upper limb CT

+ roipoly & proper thresholding



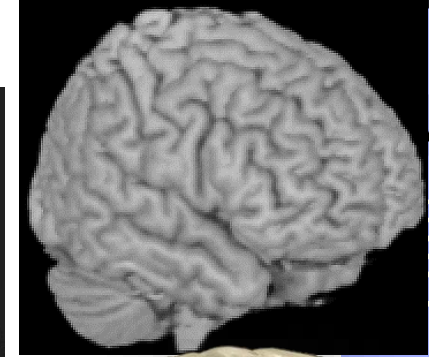
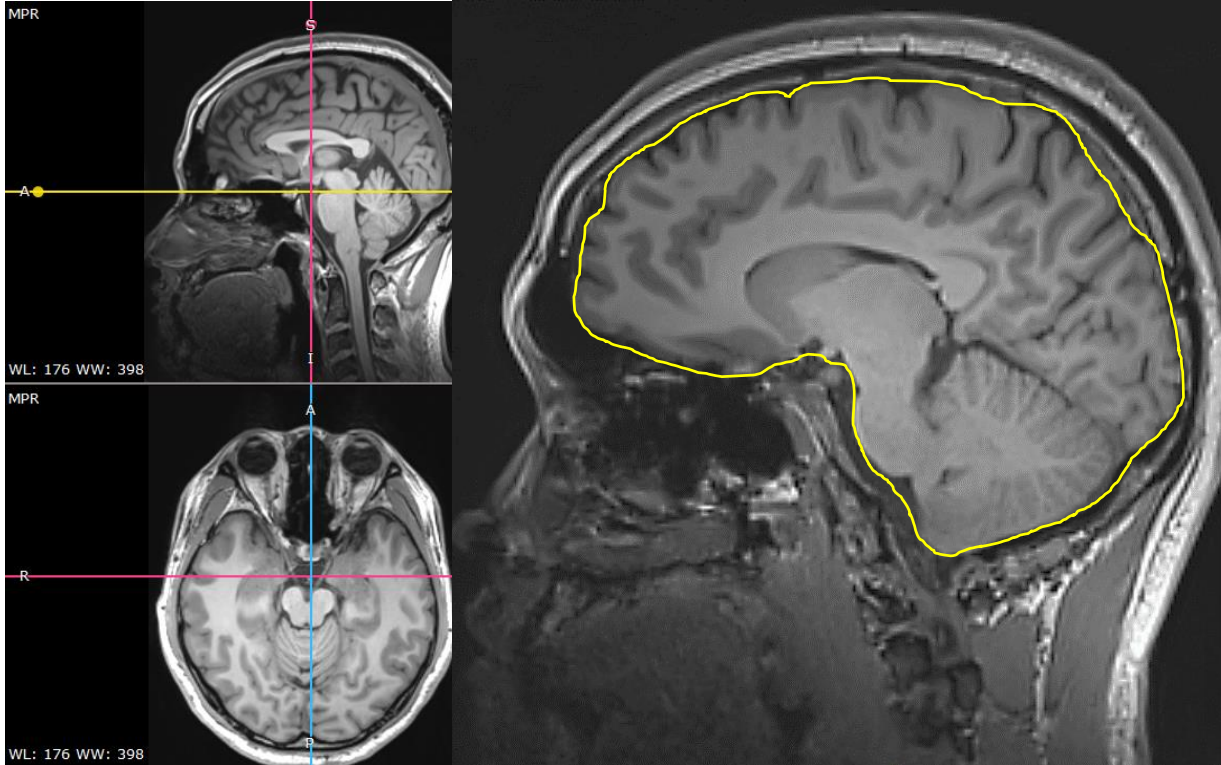
Lower limb CT

+ (roipoly) & proper thresholding



Brain MRI

+ roipoly & proper thresholding



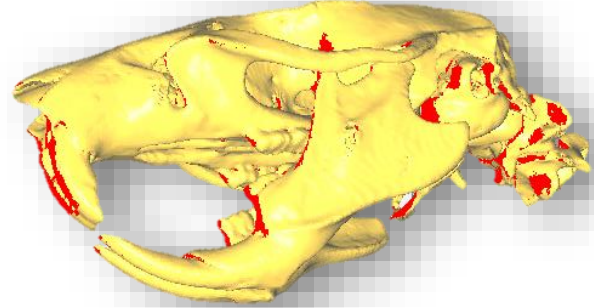
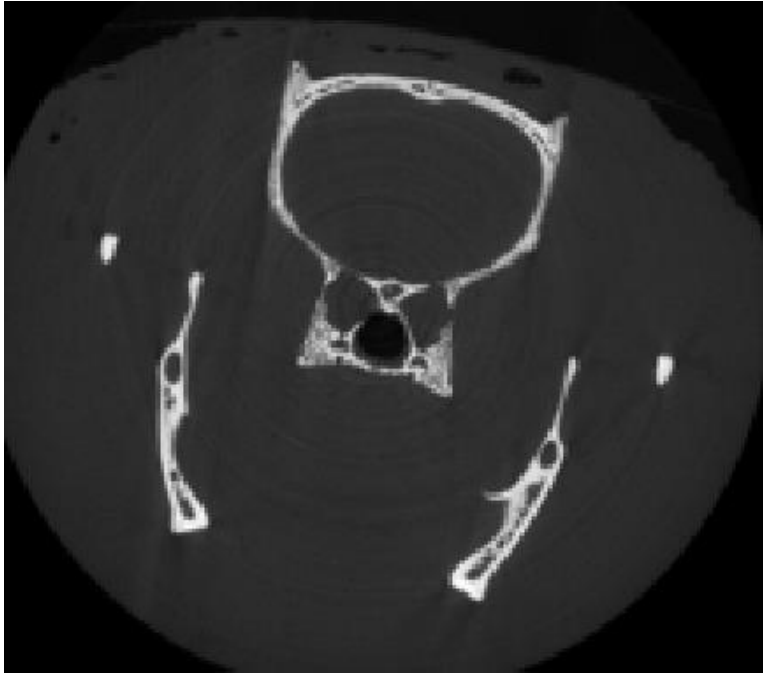
Total body CT

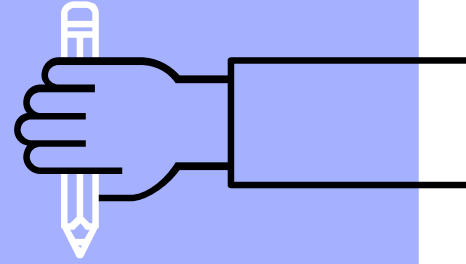
+ proper thresholding



Rat skull microCT

+ proper thresholding





THE END

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