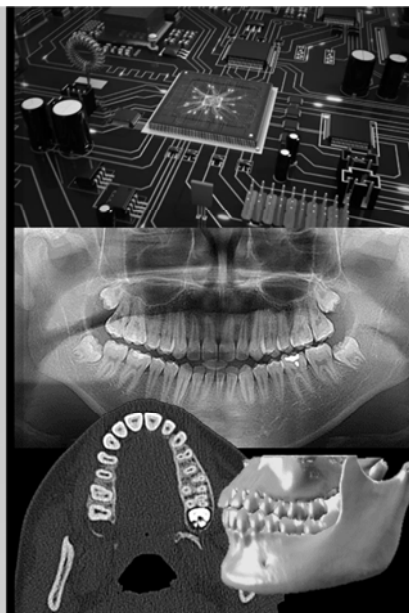


## 計算機概論 *for Dentist* PROCESSING 3D DENTAL IMAGES (CROSS SECTIONAL TOMOGRAPHY)

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## 請先下載本週上課資料

- 下載網址 [http://www.ym.edu.tw/~cflu/CFLu\\_course\\_DoDCompArch.html](http://www.ym.edu.tw/~cflu/CFLu_course_DoDCompArch.html)
- 下載第16週 [ 影像資料 ] [DentalCT.zip](#)
- 下載第16週 [ 上課資料 ] [CAmaterials\\_L16.zip](#)

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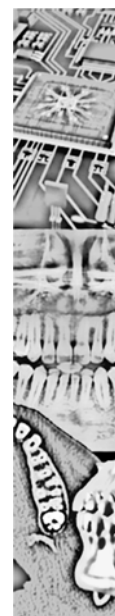


## 三維物件處理

- 3D modeling using MATLAB
- STL (Stereolithography) format for 3D printing

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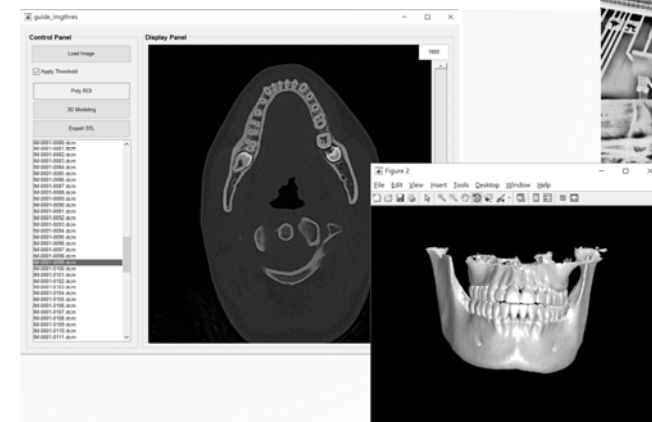
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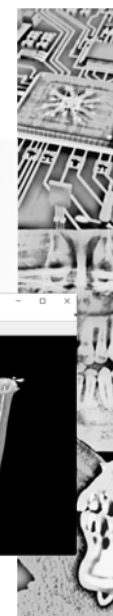
## 使用GUIDE建立GUI

- 可讀取與切換多張DICOM影像
- 可即時測試不同thresholding數值
- 可進一步加上roipoly的手動圈選效果
- 可建立3D模型
- 輸出可進行3D列印之STL檔案

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## 3D MODELING ISOSURFACE & PATCH

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## 3D RENDERING

### • Surface Rendering

- A binary rendering technique (A pixel is within a certain threshold or not).
- Threshold can be rendered into surfaces (**isosurface**)

thresholding  
+ roipoly

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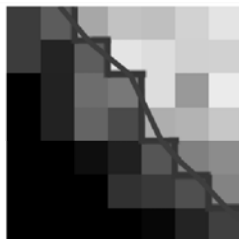
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## THRESHOLD BASED RENDERING

- Pixels at tissue interfaces may not be correctly classified.

Primary  
Isosurface

Reconstructed  
Isosurface



high threshold



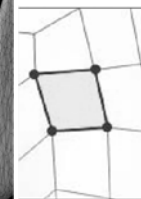
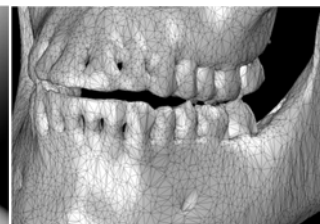
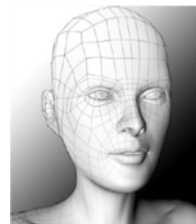
low threshold

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## POLYGONAL MODELING OF SURFACE

- Polygons consists of vertices, edge and faces.
- Marching cubes algorithm: One of the first surface rendering algorithms



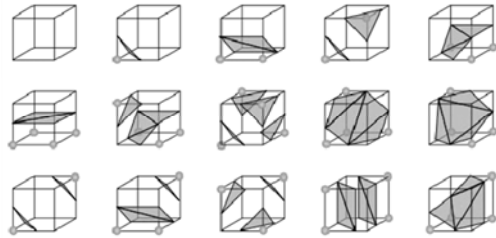
- Vertex
- Edge
- Face

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## MARCHING CUBES ALGORITHM

- Surfaces are arranged in triangles
- Algorithm calculates where surface crosses the voxel, "marching" from one cube to the other.



Lorensen et al, Computer Graphics, 1987.

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## MATLAB ISOSURFACE

isosurface Isosurface extractor.

`[F,V] = isosurface(X,Y,Z,V,ISOVALUE)` computes isosurface geometry for data `V` at isosurface value `ISOVALUE`. Arrays `(X,Y,Z)` specify the points at which the data `V` is given. The struct `FV` contains the faces and vertices of the isosurface and can be passed directly to the `PATCH` command.

`[F,V] = isosurface(V,ISOVALUE)` assumes `[X Y Z] = meshgrid(1:N, 1:M, 1:P)` where `[M,N,P]=SIZE(V)`.

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## PATCH

patch Create one or more filled polygons

`patch(X,Y,C)` creates one or more filled polygons using the elements of `X` and `Y` as the coordinates for each vertex. `patch` connects the vertices in the order that you specify them. To create one polygon, specify `X` and `Y` as vectors. To create multiple polygons, specify `X` and `Y` as matrices where each column corresponds to a polygon. `C` determines the polygon colors.

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## LISTBOX – MULTIPLE SELECTION

```
Inspector: matlab.ui.control.UIListbox
FontUnits: points
FontWeight: normal
ForegroundColor: [black]
HandleVisibility: on
HorizontalAlignment: center
InnerPosition: [0.05 0.019 0.887 0.66...]
Interruptible: [x] On
KeyPressFcn:
KeyReleaseFcn:
ListboxTop: 1.0
Max: 2.0
Min: 0.0
OuterPosition: [0.05 0.019 0.887 0.66...]
Position: [0.05 0.019 0.887 0.66...]

213 slice=get(handles.imglist,'value');
214 img=handles.Data.img(:,:,slice);

IM-0001-0025.dcm
IM-0001-0026.dcm
IM-0001-0027.dcm
IM-0001-0028.dcm
IM-0001-0029.dcm
IM-0001-0030.dcm
IM-0001-0031.dcm
IM-0001-0032.dcm
IM-0001-0033.dcm
IM-0001-0034.dcm
IM-0001-0035.dcm
IM-0001-0036.dcm
IM-0001-0037.dcm
IM-0001-0038.dcm
IM-0001-0039.dcm
IM-0001-0040.dcm
IM-0001-0041.dcm
IM-0001-0042.dcm

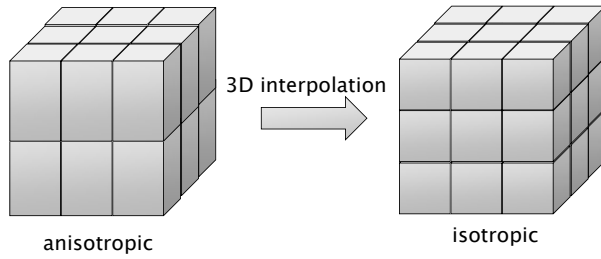
Slice =
29 30 31 32 33
```

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## 3D MODELING

```
222 % convert image volume to isotropic
223 - img=isotropicvol(img,0.36,0.36,0.50);
```

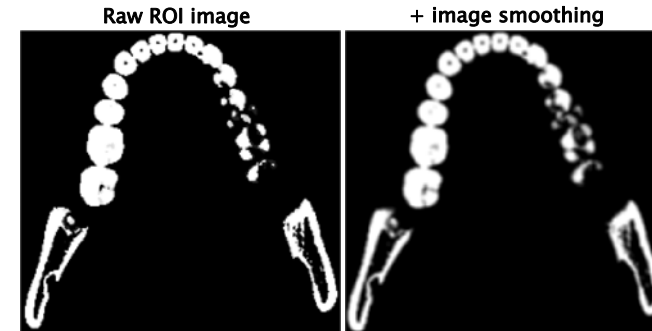


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## IMAGE SMOOTHING

```
224 % smooth image volume
225 - img=smooth3(img);
```



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## 3D MODELING

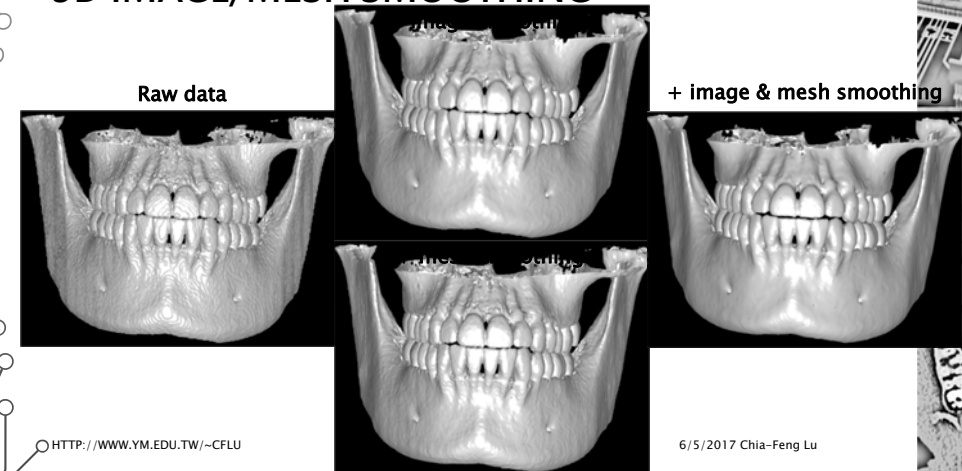
```
227 - [f,v] = isosurface(img);
228 % [f,v] = reducepatch(f,v,0.1);
229 - v=meshsmooth(f,v); % apply mesh smoothing
230
231 figure('color',[0 0 0]),
232 patch('parent',gca,'faces',f,'vertices',v,...
233       'FaceColor',[.99 .99 .99],'edgecolor','none');
234 set(gca,'zdir','reverse','visible','off')
235 axis equal
236
237 lighting gouraud
238 view(0,0)
239 camlight(0,0)
240 - camlight(180,0)
```

Light creates shadows for 3D models

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## 3D IMAGE/MESH SMOOTHING



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# TRY IT!

開啟並執行CAMaterial\_L16\guide\_imgthres.m



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# STL (STEREOLITHOGRAPHY) FORMAT FOR 3D PRINTING

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# STL FORMAT

## • ASCII STL

請以記事本開啟CAMaterial\_L16\ascii.stl

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

```
facet normal ni nj nk
  outer loop
    vertex v1x v1y v1z
    vertex v2x v2y v2z
    vertex v3x v3y v3z
  endloop
endfacet
```

- The file concludes with endsolid name

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# 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
```

ASCII格式檔案大小較大!

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# EXPORT STL

```
248 function exportstl_Callback(hObject, eventdata, handles)
249 % hObject handle to exportstl (see GCBO)
250 % eventdata reserved - to be defined in a future version of MATLAB
251 % handles structure with handles and user data (see GUIDATA)
252 [filename, filepath]=uiputfile('*.stl','Please select an STL file to save');
253 stlwrite([filepath filename],handles.Data.f,handles.Data.v,'mode','binary')
```

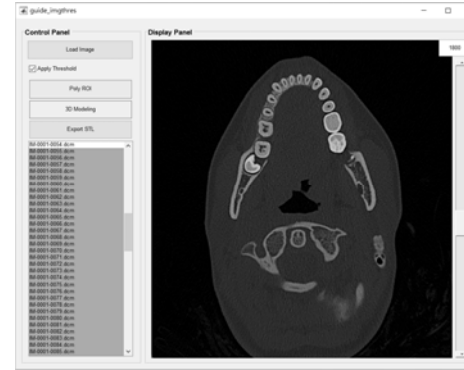
使用stlwrite function (released by Sven Holcombe)

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# TRY IT!

開啟並執行CAmaterial\_L16\guide\_imgthres.m

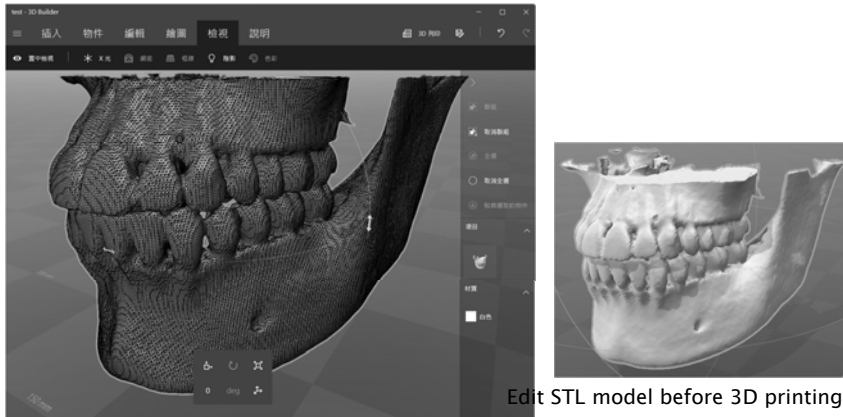


執行完[3D Modeling]後  
請按下[Export STL]輸出檔案

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# WINDOWS 10 3D BUILDER



Edit STL model before 3D printing

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# THE END

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