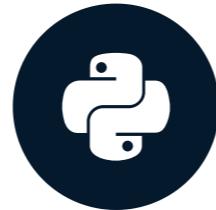


Image data

BIOMEDICAL IMAGE ANALYSIS IN PYTHON



Stephen Bailey

Instructor

Biomedical imaging: more than a century of discovery

1895



2017



Course objectives

Exploration	Masks and Filters
<ul style="list-style-type: none">• Loading images• N-D data• Subplots	<ul style="list-style-type: none">• Intensity distributions• Convolutions• Edge detection
Measurement	Image Comparison
<ul style="list-style-type: none">• Labelling• Multi-object measurement• Morphology	<ul style="list-style-type: none">• Transformations• Resampling• Cost functions• Normalization

Toolbox

- `ImageIO`
- `NumPy`
- `SciPy`
- `matplotlib`

Loading images

- `imageio` : read and save images
- `Image` objects are NumPy arrays.

```
import imageio  
im = imageio.imread('body-001.dcm')  
type(im)
```

```
imageio.core.Image
```

```
im
```

```
Image([[125, 135, ..., 110],  
      [100, 130, ..., 100],  
      ...,  
      [100, 150, ..., 100]],  
      dtype=uint8)
```

Loading images

- Slice the array by specifying values along each available dimension.

```
im[0, 0]
```

```
125
```

```
im[0:2, 0:2]
```

```
Image([[125, 135],  
       [100, 130]],  
      dtype=uint8)
```

Metadata

- **Metadata:** the who, what, when, where and how of image acquisition
- Accessible in `Image` objects through the `meta` dictionary attribute

```
im.meta
```

```
im.meta['Modality']
```

```
im.meta.keys()
```

```
Dict([('StudyDate', '2017-01-01',
       ('Modality', 'MR'),
       ('PatientSex', F),
       ...
       ('shape', (256, 256)))]
```

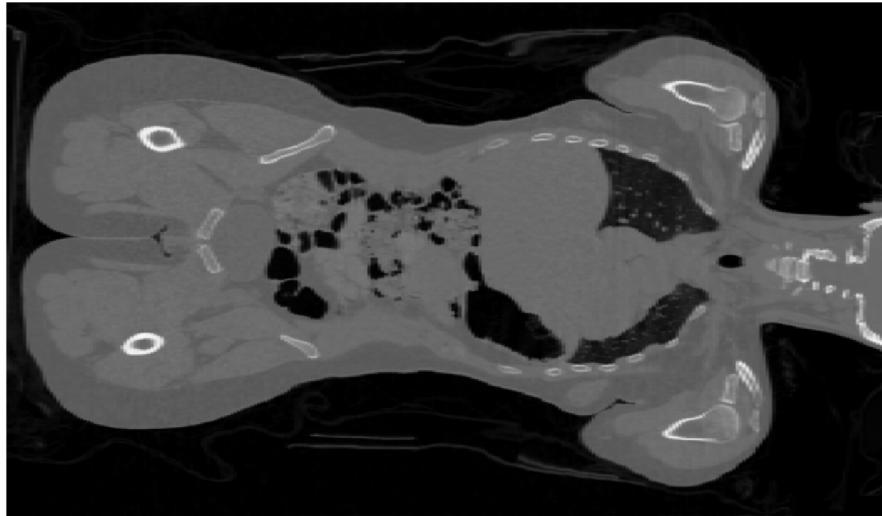
```
'MR'
```

```
odict_keys(['StudyDate',
            'SeriesDate',
            'PatientSex',
            ...
            'shape'])
```

Plotting images

- Matplotlib's `imshow()` function displays 2D image data
- Many colormaps available but often shown in grayscale (`cmap='gray'`)
- Axis ticks and labels are often **not** useful for images

```
import matplotlib.pyplot as plt
plt.imshow(im, cmap='gray')
plt.axis('off')
plt.show()
```

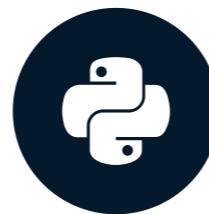


Let's practice!

BIOMEDICAL IMAGE ANALYSIS IN PYTHON

N-dimensional images

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Images of all shapes and sizes

im[row, col]



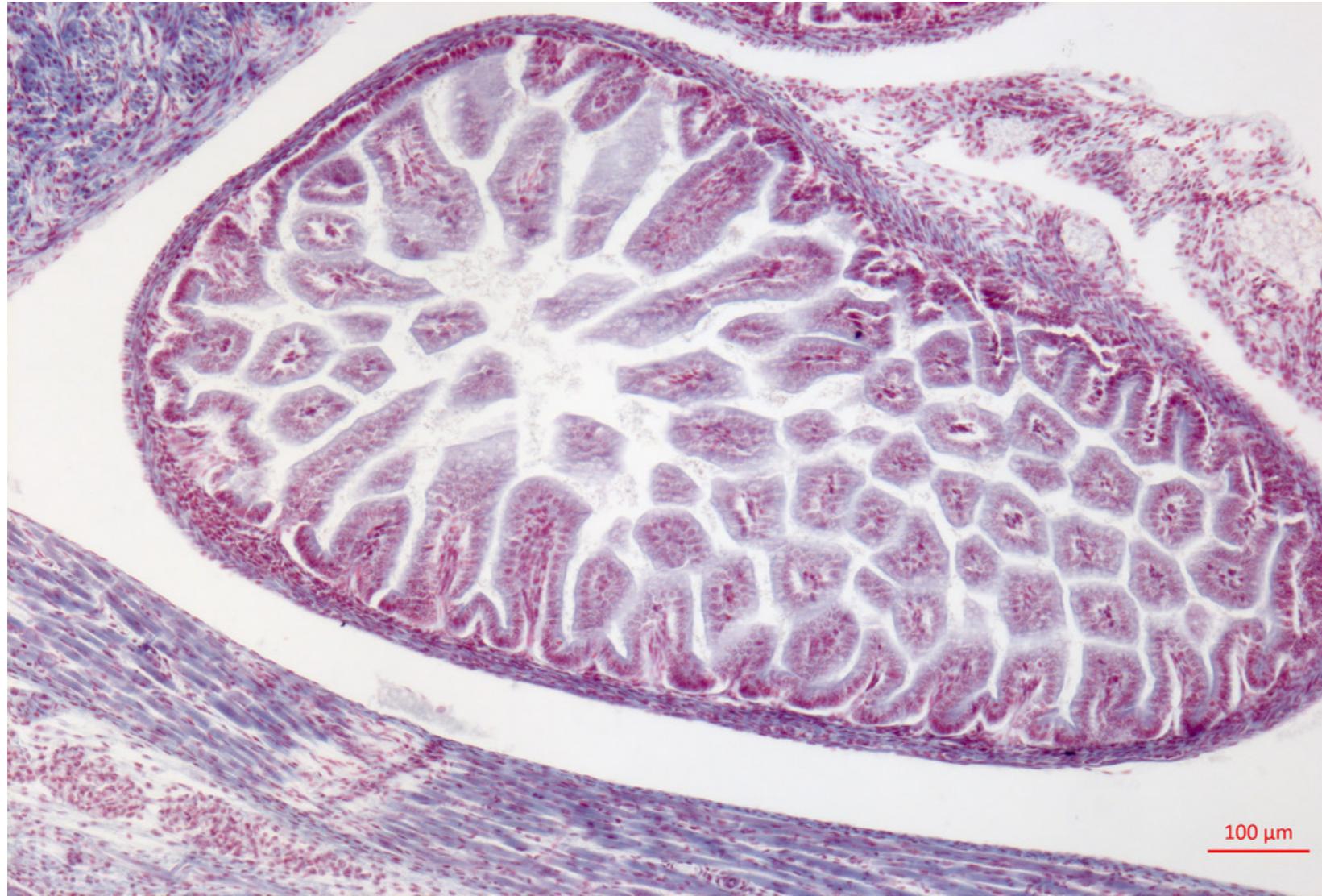
Images of all shapes and sizes

```
vol[pln, row, col]
```



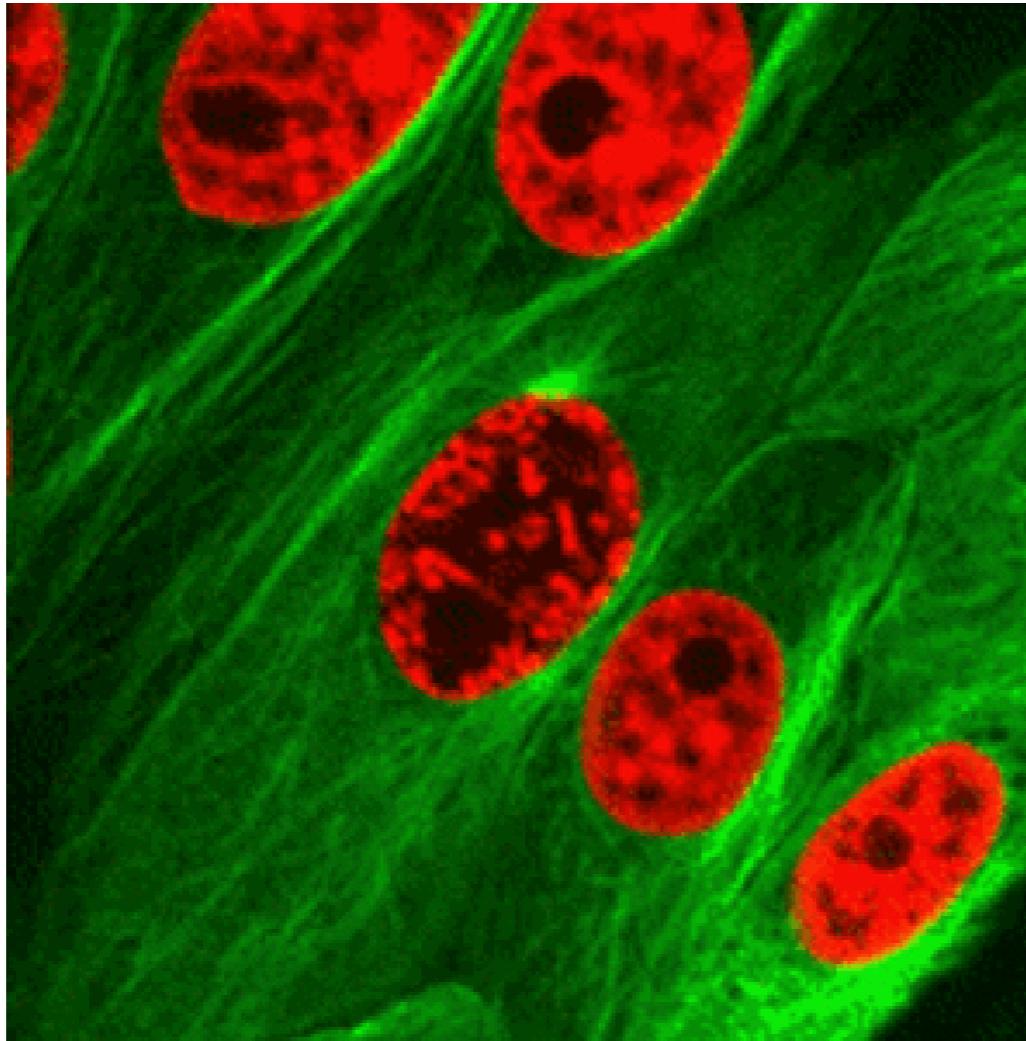
Images of all shapes and sizes

im[row, col, ch]

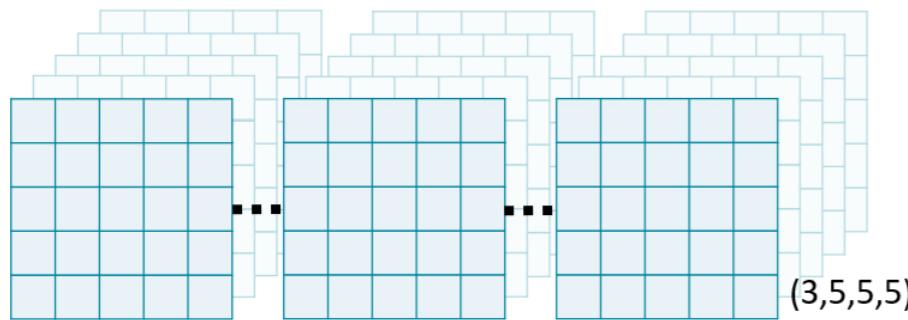
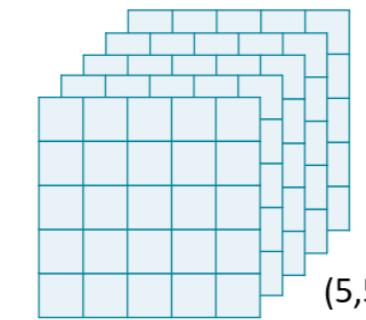
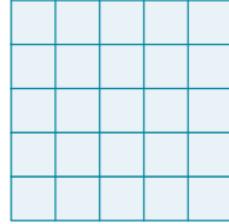


Images of all shapes and sizes

```
im_ts[time, row, col, ch]
```



N-dimensional images are stacks of arrays



```
import imageio  
import numpy as np  
im1=imageio.imread('chest-000.dcm')  
im2=imageio.imread('chest-001.dcm')  
im3=imageio.imread('chest-002.dcm')  
im1.shape
```

(512, 512)

```
vol = np.stack([im1, im2, im3])  
vol.shape
```

(3, 512, 512)

Loading volumes directly

`imageio.volread()` :

- read multi-dimensional data directly
- assemble a volume from multiple images

```
import os  
os.listdir('chest-data')
```

```
['chest-000.dcm',  
'chest-001.dcm',  
'chest-002.dcm',  
...,  
'chest-049.dcm']
```

```
import imageio  
vol = imageio.volread('chest-data')  
vol.shape
```

```
(50, 512, 512)
```

Shape, sampling, and field of view

Image shape: number of elements along each axis

```
import imageio  
vol = imageio.volread(  
    'chest-data')  
  
# Image shape (in voxels)  
n0, n1, n2 = vol.shape  
n0, n1, n2
```

(50, 512, 512)

Field of view: physical space covered along each axis

Sampling rate: physical space covered by each element

```
# Sampling rate (in mm)  
d0, d1, d2 = vol.meta['sampling']  
d0, d1, d2
```

(2, 0.5, 0.5)

```
# Field of view (in mm)  
n0 * d0, n1 * d1, n2 * d2
```

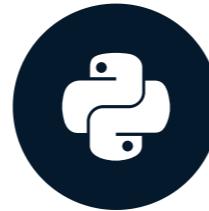
(100, 256, 256)

Let's practice!

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Advanced plotting

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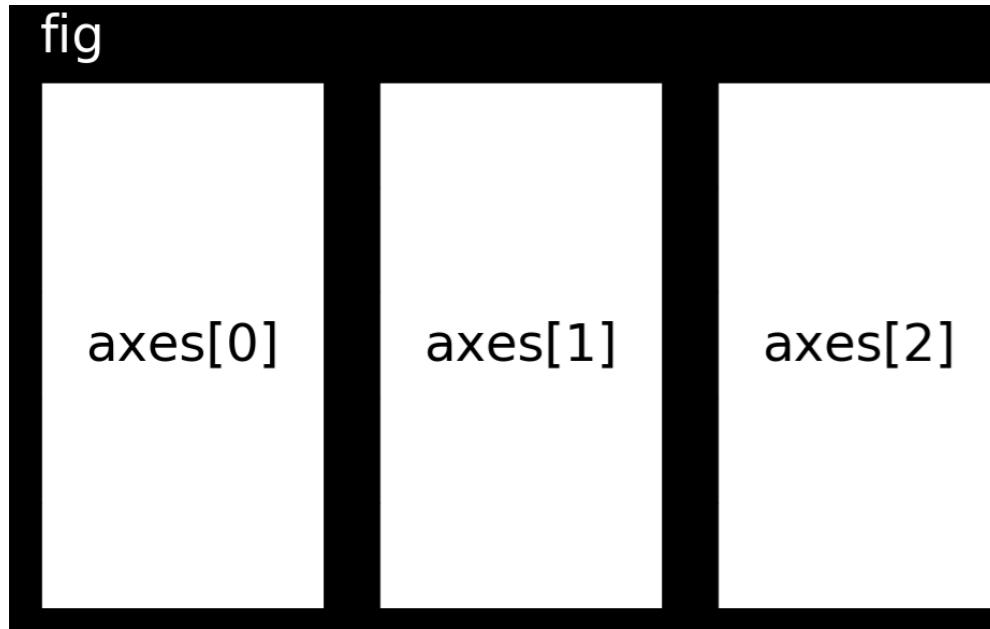
Instructor

To plot N-dimensional data slice it!



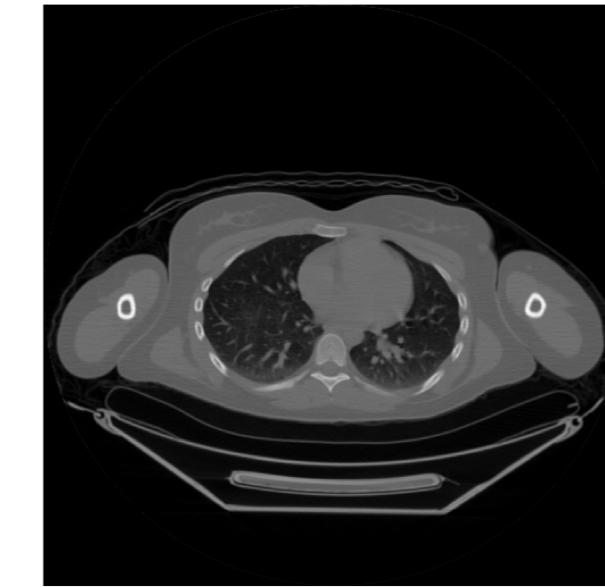
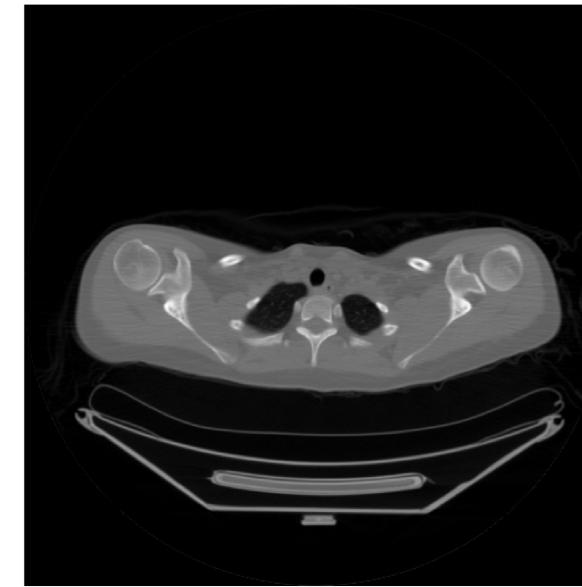
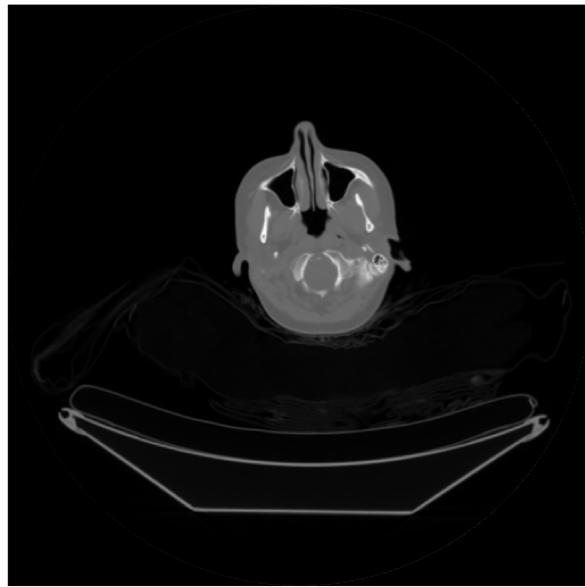
Plotting multiple images at once

`plt.subplots` : creates a figure canvas with multiple `AxesSubplots` objects.



```
import imageio
vol = imageio.volread('chest-data')
fig, axes = plt.subplots(nrows=1,
                        ncols=3)
axes[0].imshow(vol[0], cmap='gray')
axes[1].imshow(vol[10], cmap='gray')
axes[2].imshow(vol[20], cmap='gray')
for ax in axes:
    ax.axis('off')
plt.show()
```

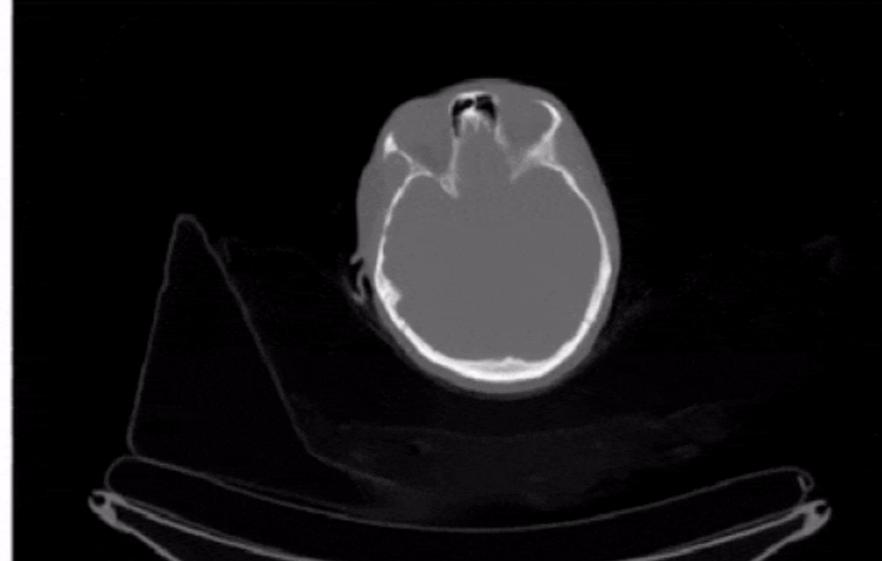
Plotting multiple images at once



Non-standard views

```
import imageio  
  
vol = imageio.volread(  
    'chest-data')  
view_1v2 = vol[pln, :, :]  
view_1v2 = vol[pln]
```

Axial



Non-standard views

```
import imageio

vol = imageio.volread(
    'chest-data')
view_1v2 = vol[pln, :, :]
view_1v2 = vol[pln]
view_0v2 = vol[:, row, :]
```

Coronal

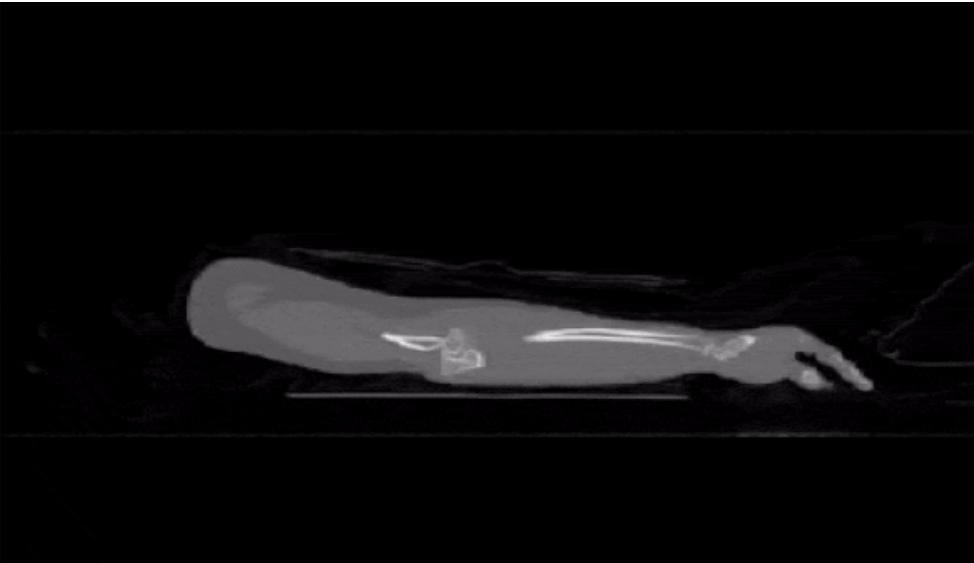


Non-standard views

```
import imageio

vol = imageio.volread(
    'chest-data')
view_1v2 = vol[pln, :, :]
view_1v2 = vol[pln]
view_0v2 = vol[:, row, :]
view_0v1 = vol[:, :, col]
```

Sagittal



Modifying the aspect ratio

Pixels may adopt any aspect ratio:

4:1

16:9

1:1

```
im = vol[:, :, 100]  
d0, d1, d2 = vol.meta['sampling']  
d0, d1, d2
```

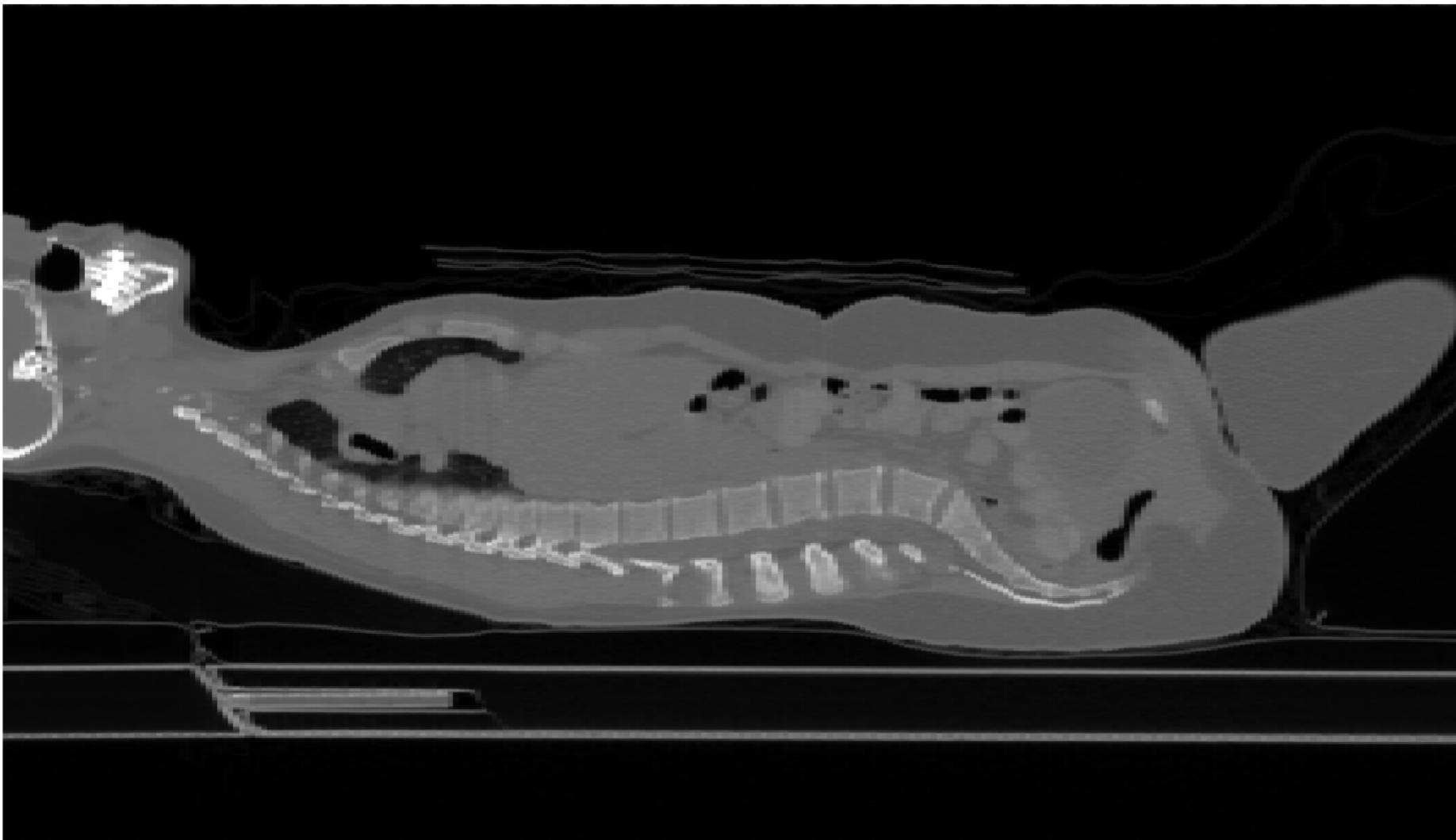
(2, 0.5, 0.5)

```
asp = d0 / d1  
asp
```

3

```
plt.imshow(im, cmap='gray',  
          aspect=asp)  
plt.show()
```

Modifying the aspect ratio



Let's practice!

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