BIOMEDICAL IMAGE ANALYSIS IN PYTHON

# Image Data

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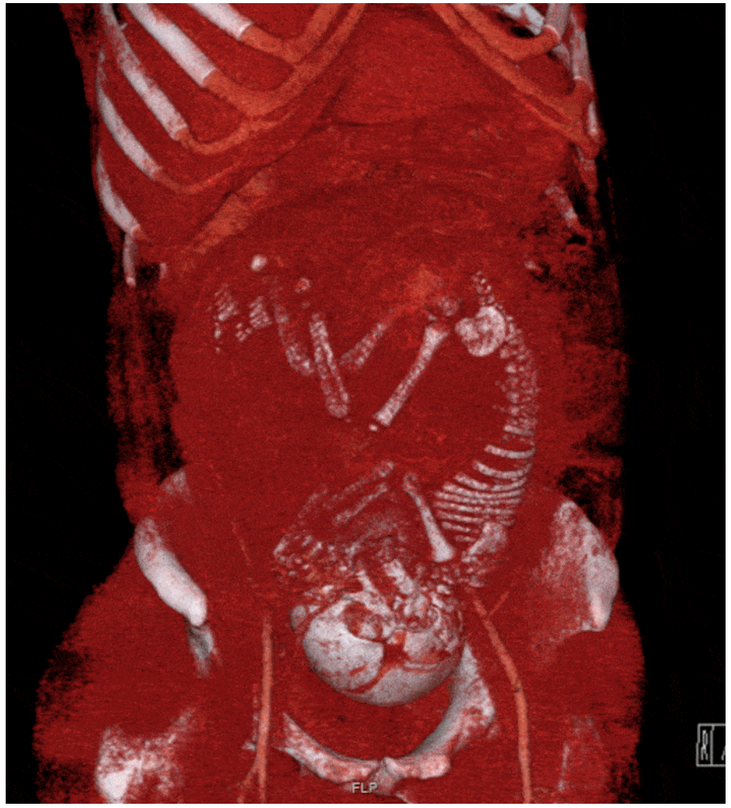
Instructor

# Biomedical imaging: more than a century of discovery

1895


2017



# Course objectives

**Exploration**

- Loading images
- N-D data
- Subplots

**Masks and Filters**

- Intensity distributions
- Convolutions
- Edge detection

**Measurement**

- Labelling
- Multi-object measurement
- Morphology

**Image Comparison**

- Transformations
- Resampling
- Cost functions
- Normalization

**Toolbox**

- ImageIO
- NumPy
- SciPy
- matplotlib

# Loading images

- `imageio`: read and save images
- `Image` objects are NumPy arrays.
- Slice the array by specifying values along each available dimension.

```
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)
```

```
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

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

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

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

# Plotting images

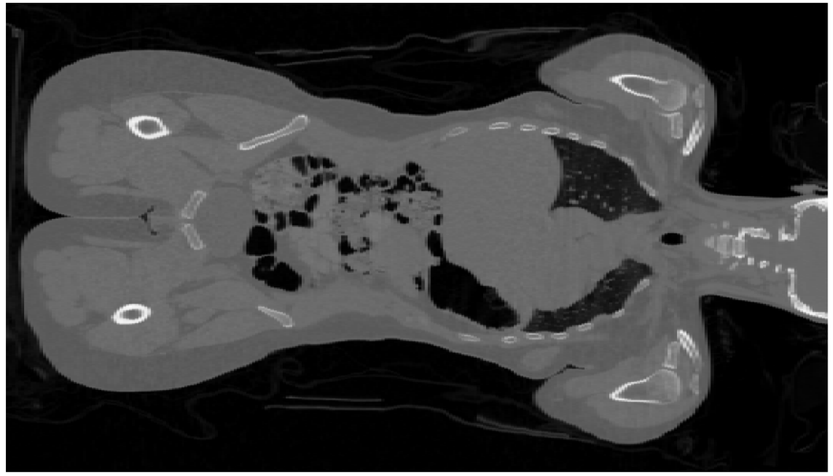
- Matplotlib's `imshow()` function displays 2D image data
- Many colormaps available but often shown in grayscale (`cmap='gray'`)
- Axis ticks and labels are often **not** useful for images

```
import matplotlib.pyplot as plt

plt.imshow(im, cmap='gray')

plt.axis('off')

plt.show()
```



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# Let's practice!

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# N-dimensional images

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# Images of all shapes and sizes

```
im[row, col]
```

# Images of all shapes and sizes

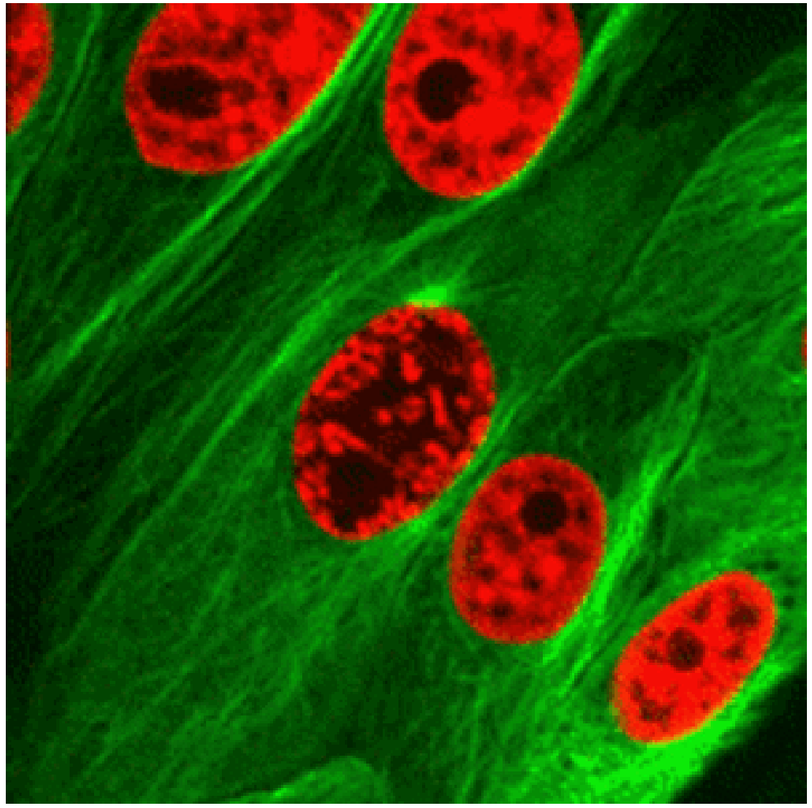
```
vol[pln, row, col]
```

# Images of all shapes and sizes

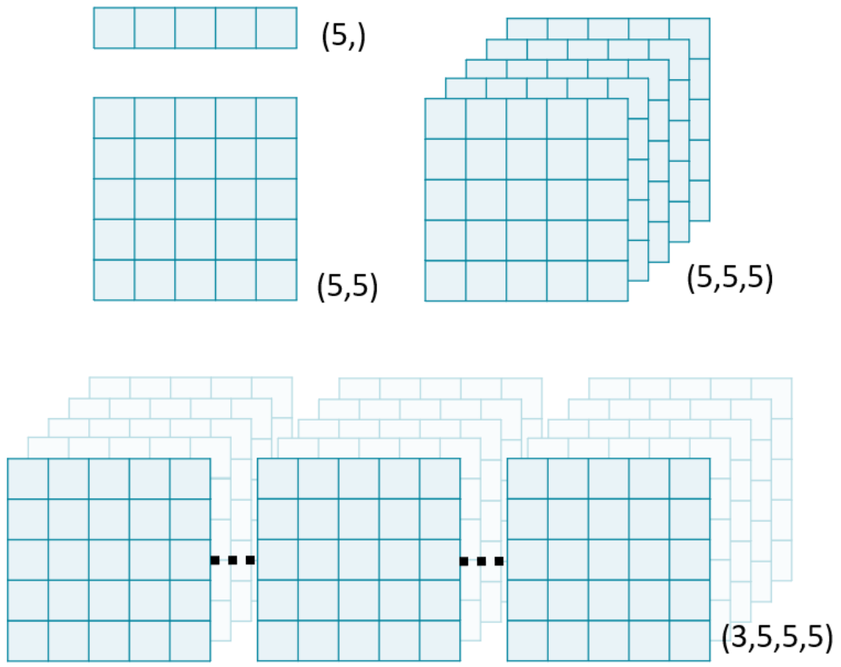
```
im[row, col, ch]
```

# 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
- **Sampling rate**: physical space covered by each element
- **Field of view**: physical space covered 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)
```

```
# 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)
```

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# Let's practice!

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# Advanced plotting

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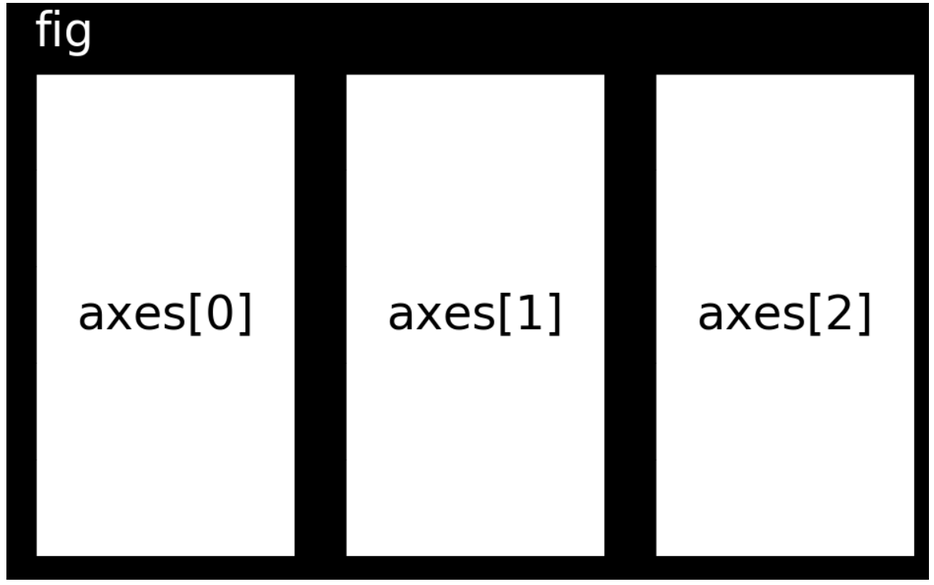
# To plot N-dimensional data slice it!

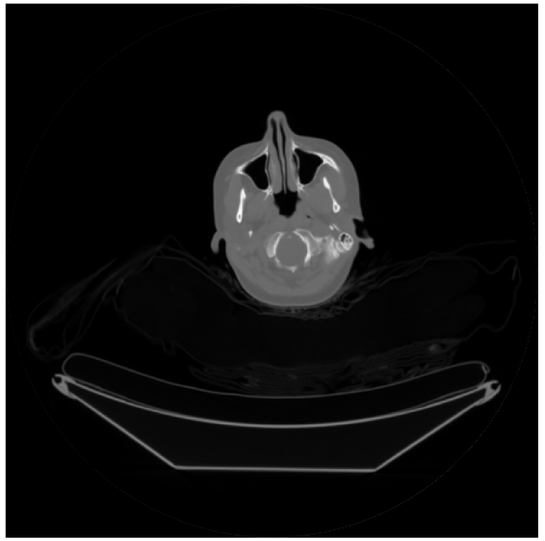
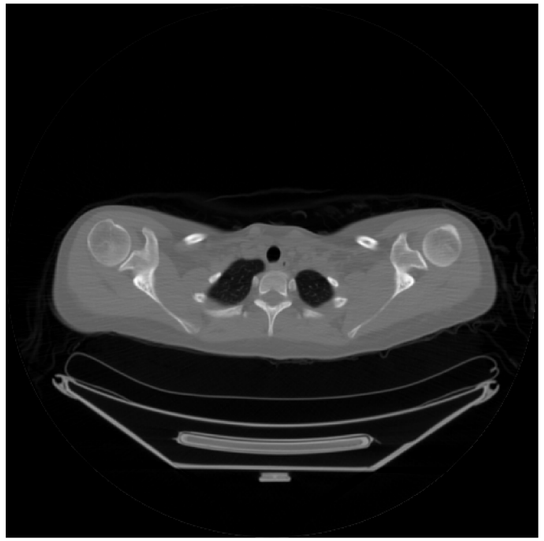
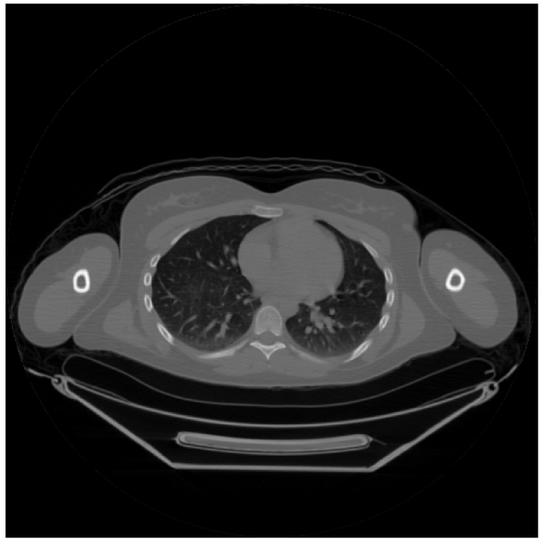
# Plotting multiple images at once

`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()
```

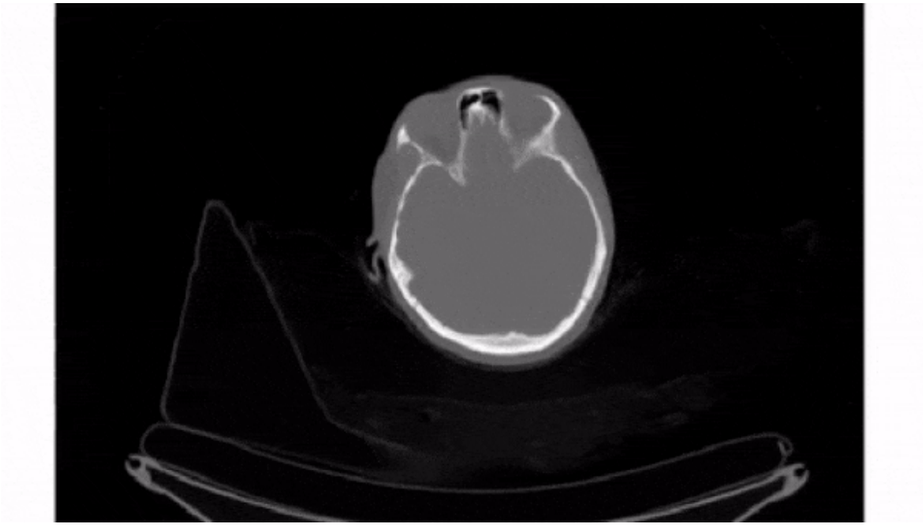
# Plotting multiple images at once

# Non-standard views

```
import imageio

vol = imageio.volread('chest-data')

view_1v2 = vol[pln, :, :]
view_1v2 = vol[pln]
```

$Axial$



# Non-standard views

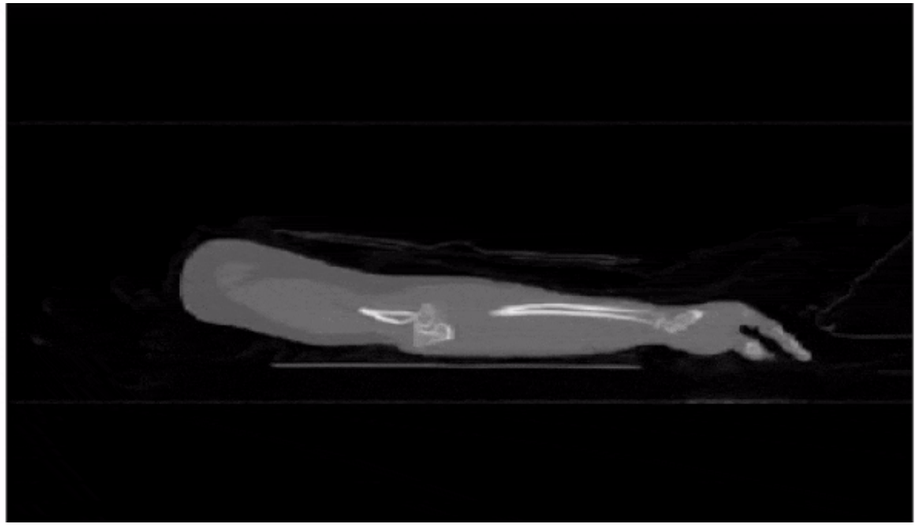
```
import imageio

vol = imageio.volread('chest-data')

view_1v2 = vol[pln, :, :]
view_1v2 = vol[pln]

view_0v2 = vol[:, row, :]
```

*Coronal*

# Non-standard views

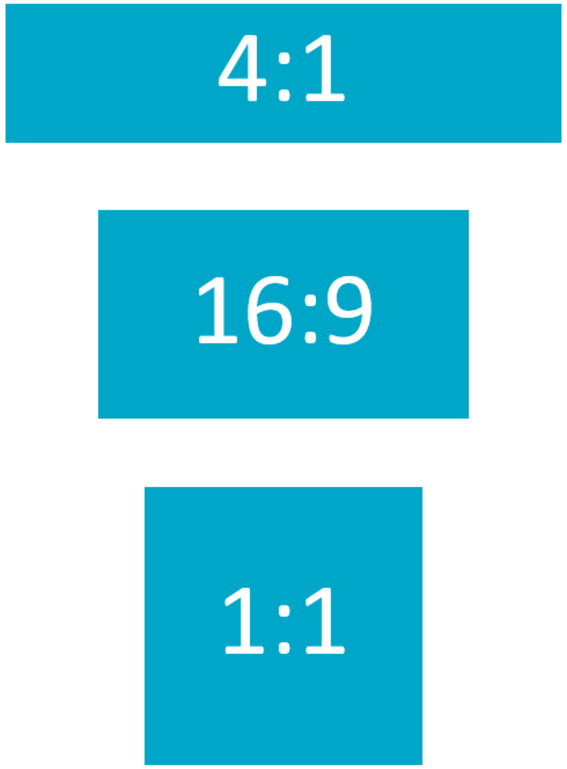
```
import imageio

vol = imageio.volread('chest-data')

view_1v2 = vol[pln, :, :]
view_1v2 = vol[pln]

view_0v2 = vol[:, row, :]

view_0v1 = vol[:, :, col]
```

*Sagittal*



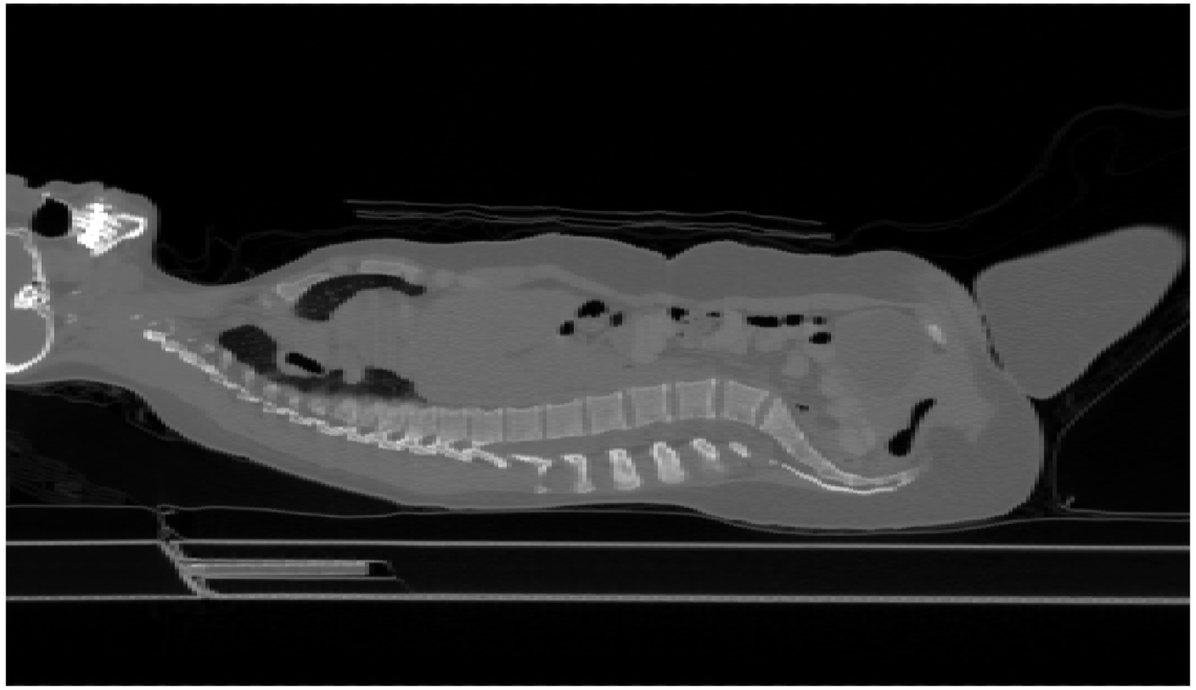
# Modifying the aspect ratio

Pixels may adopt any aspect ratio:




```
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



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