Image data

BIOMEDICAL IMAGE ANALYSIS IN PYTHON

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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.

```
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
```

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

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

```
'MR'
```

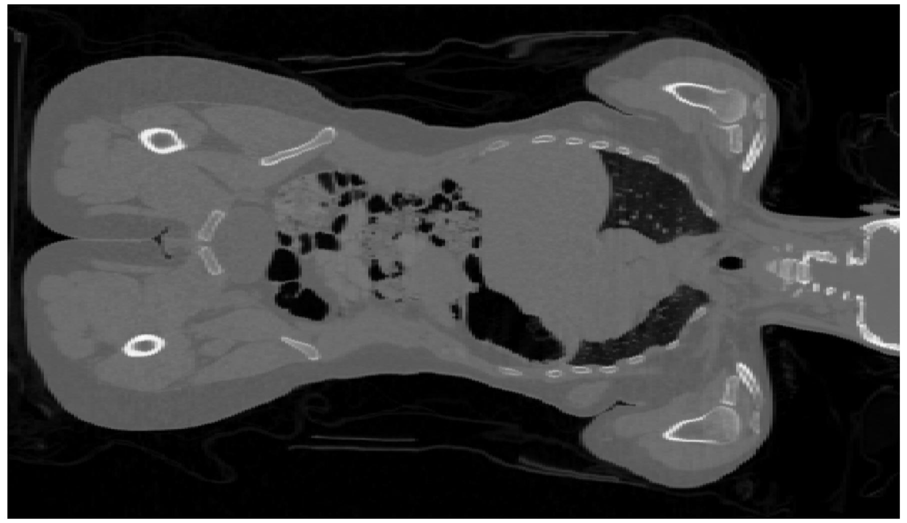
```
im.meta.keys()
```

```
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

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



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

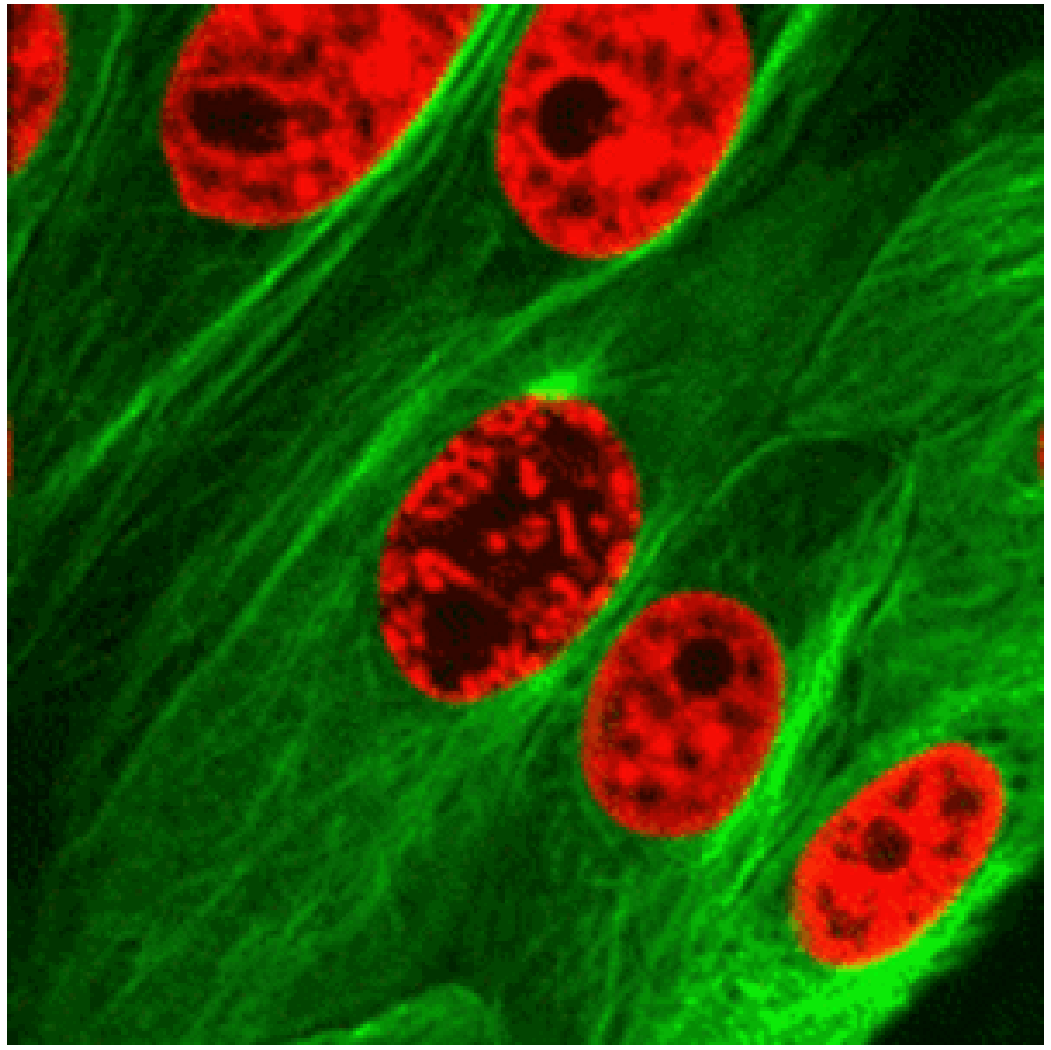
```
vol[pln, row, col]
```

Images of all shapes and sizes

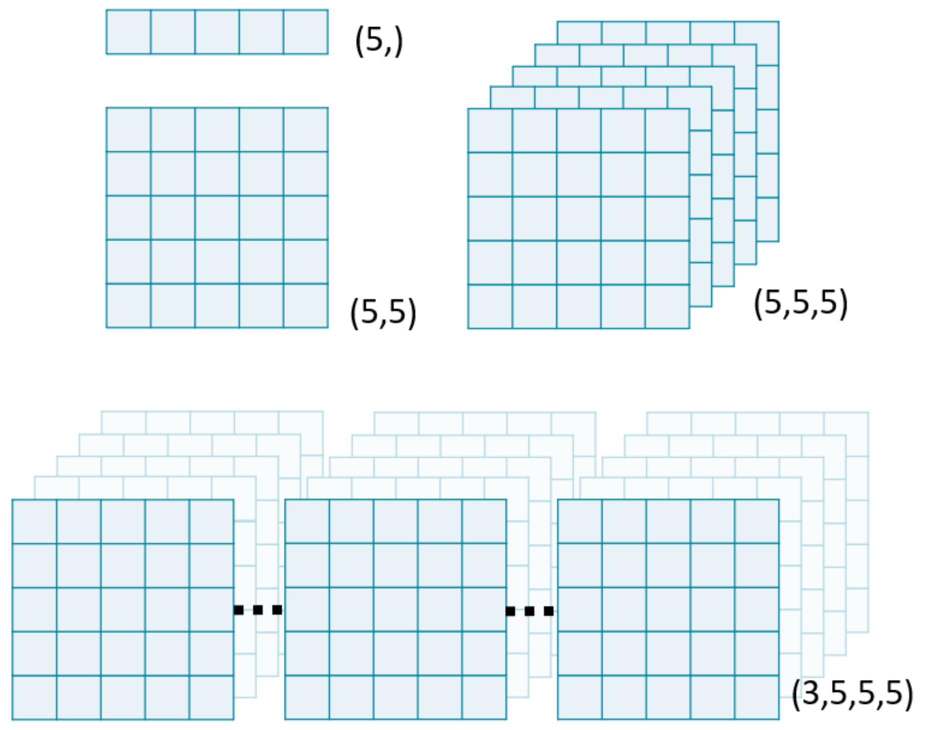
`im[row, col, ch]`

Images of all shapes and sizes

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



N-dimensional images are stacks of arrays



```python
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)
```

```python
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

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

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

```python
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

```python
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

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

```
(2, 0.5, 0.5)
```

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

```
(100, 256, 256)
```

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Advanced plotting

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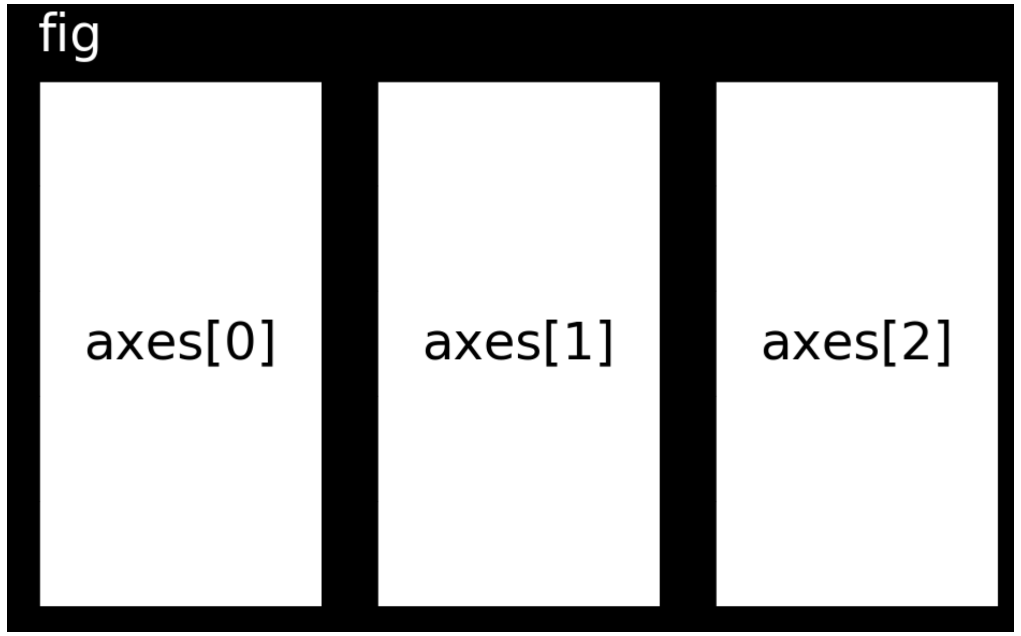
To plot N-dimensional data slice it!

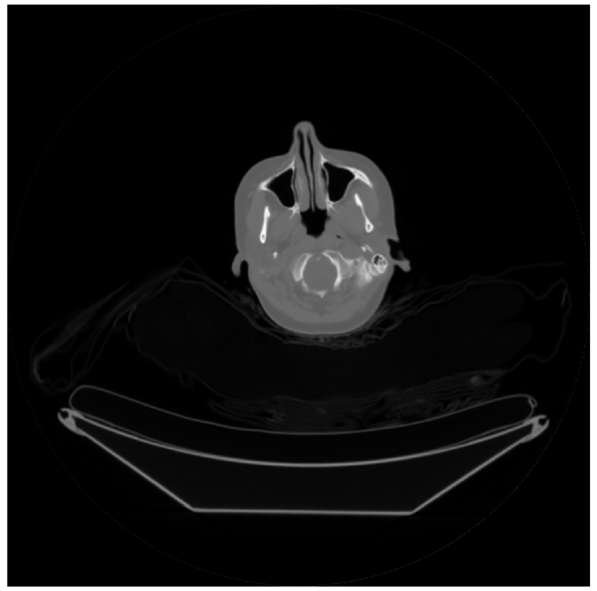
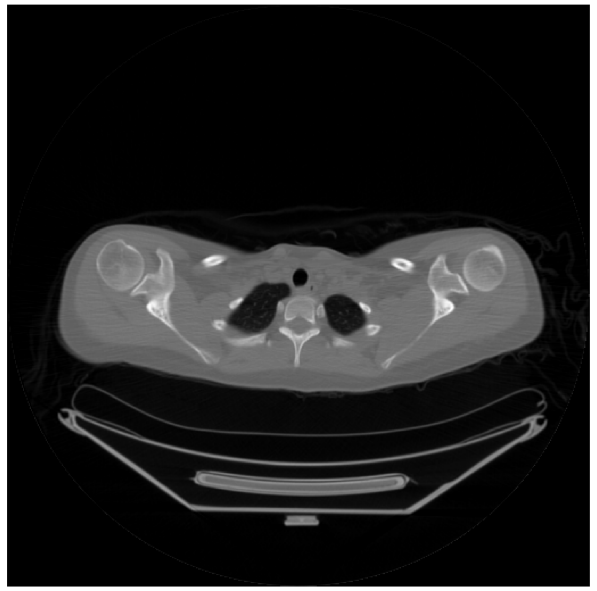
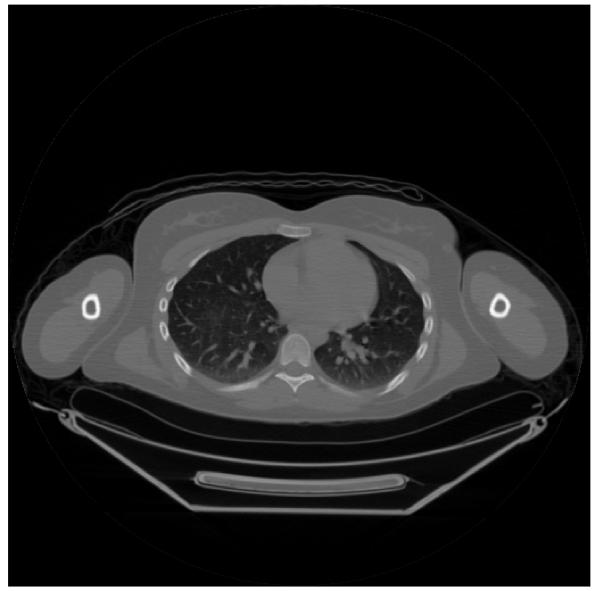
Plotting multiple images at once

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



```python
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()
```

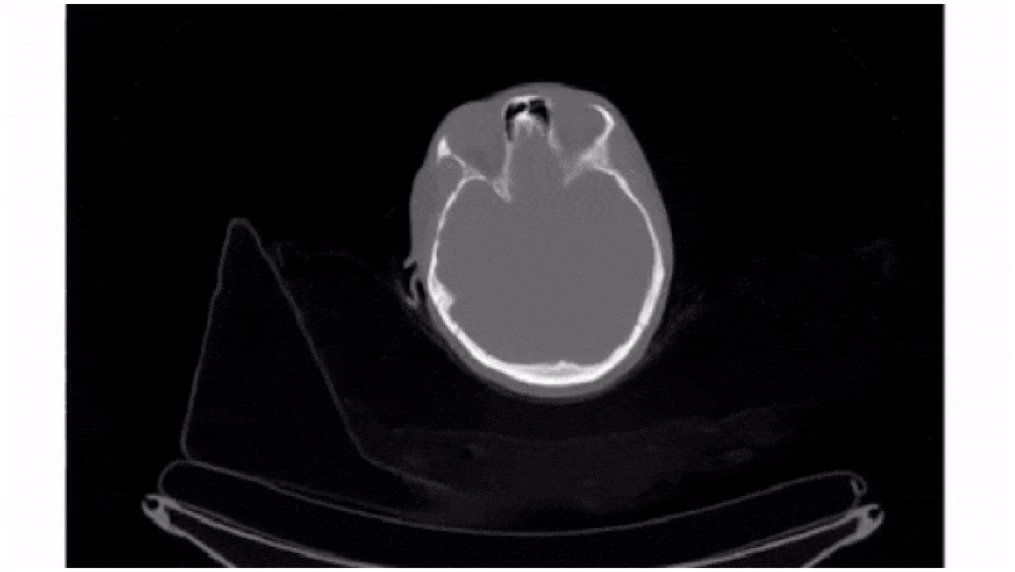
Plotting multiple images at once

Non-standard views

```
import imageio

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

Axial



Non-standard views

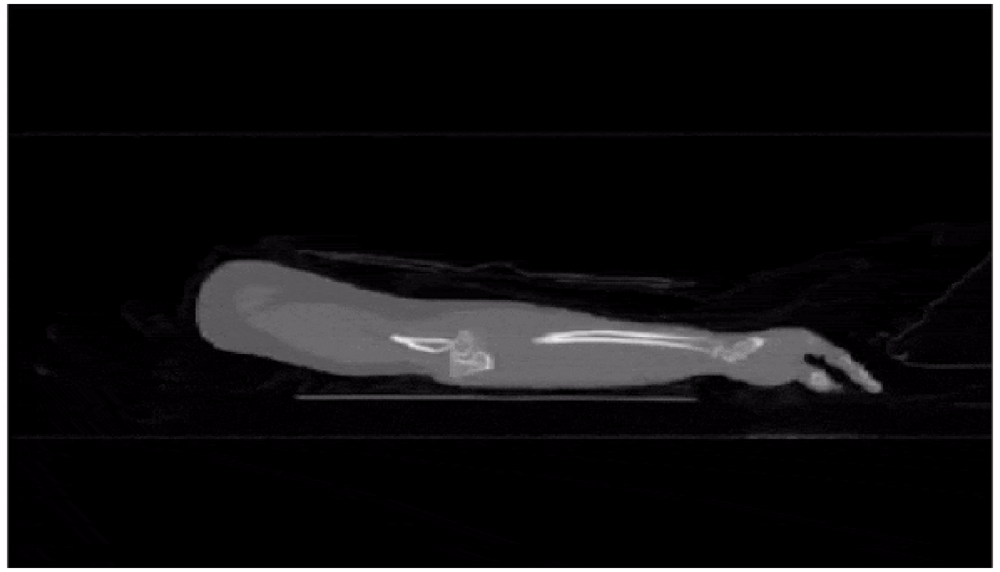
```python
import imageio

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

Coronal

Non-standard views

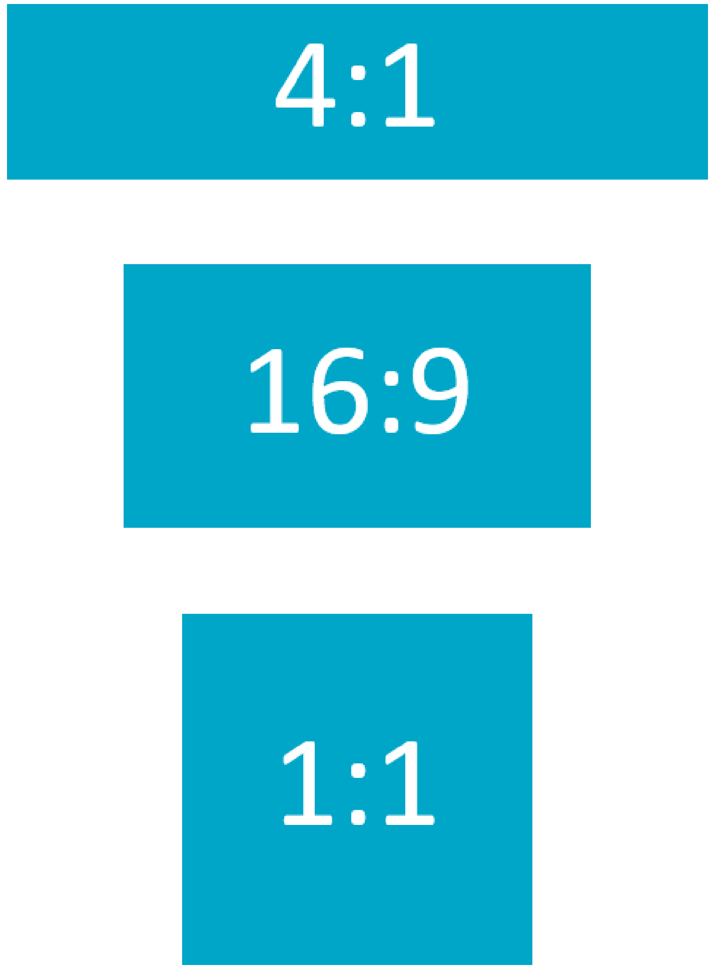
```
import imageio

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
```

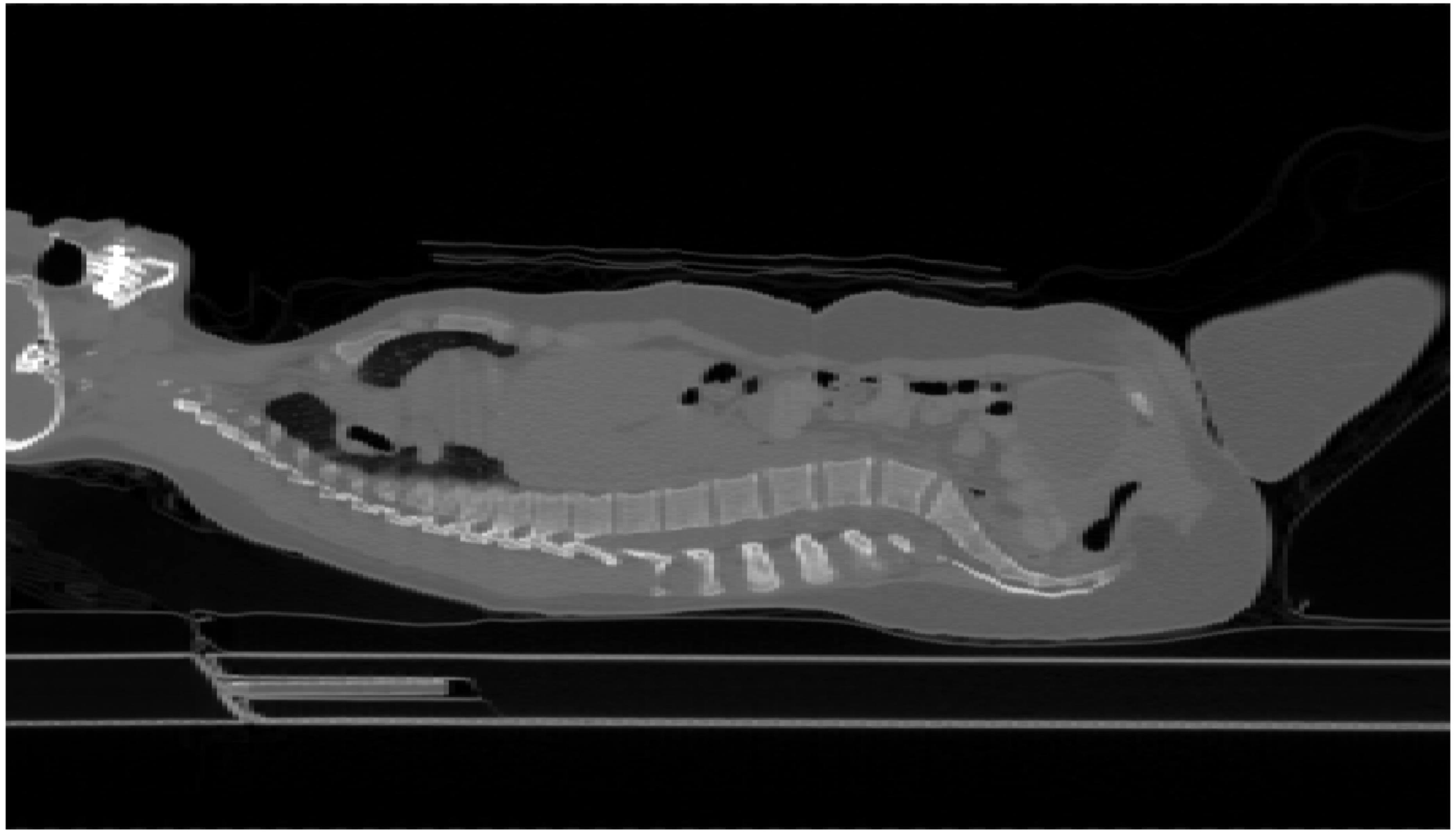
```
(2, 0.5, 0.5)
```

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

```
3
```

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

Modifying the aspect ratio



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