Medical Imaging Modalities

Methods in Medical Image Analysis - Spring 2019
16-725 (CMU RI) : BioE 2630 (Pitt)
Dr. John Galeotti

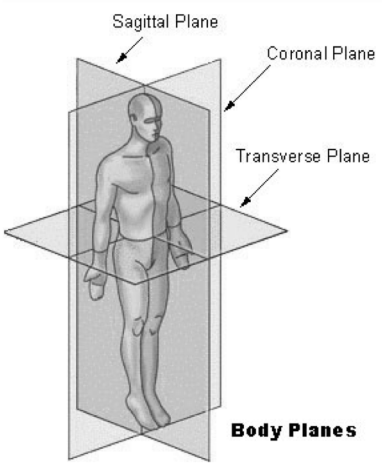
The content of these slides by John Galeotti, © 2012-2019 Carnegie Mellon University (CMU), was made possible in part by NIH NLM contract# HHSN276201000580P, and is licensed under a Creative Commons Attribution 3.0 Unported License. To view a copy of this license, visit http://creativecommons.org/licenses/by/3.0/ or send a letter to Creative Commons, 171 2nd Street, Suite 300, San Francisco, California, 94105, USA. Permissions beyond the scope of this license may be available either from CMU or by emailing itk@galeotti.net.
The most recent version of these slides may be accessed online via http://itk.galeotti.net/

Anatomical Axes

- Superior = head
- Inferior = feet

- Anterior = front
- Posterior = back

- Proximal = central
- Distal = peripheral



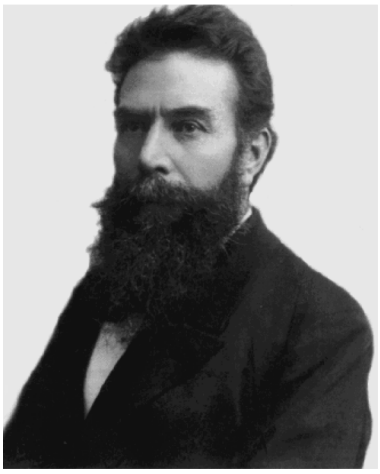
2

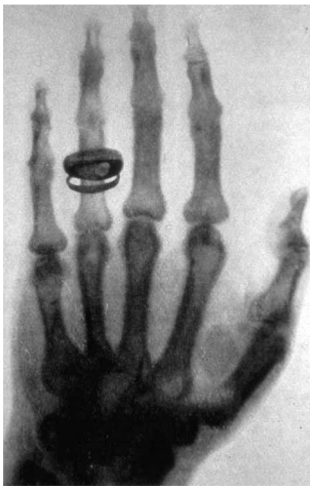
Imaging Modalities

- Camera: Microscope, Endoscope, etc.
- X-Ray
- CT
- Nuclear Medicine
- Ultrasound
- MRI
- …

3

1896: The X-Ray

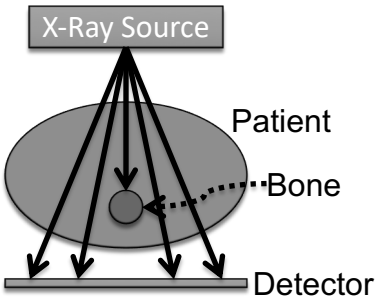




4

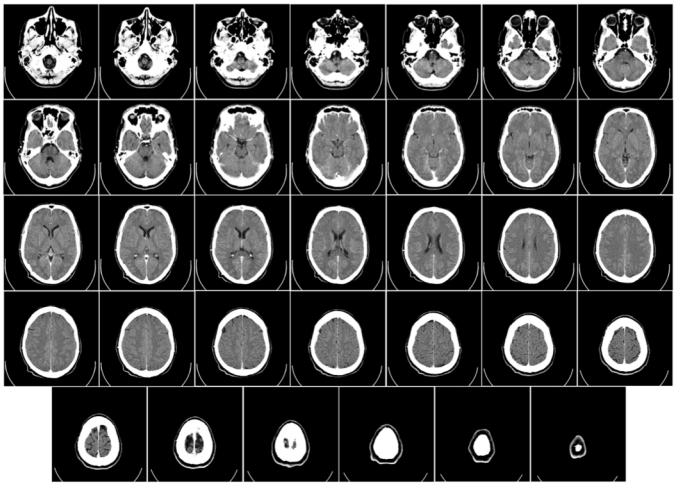
X-Ray & Fluoroscopic Images

- Projection of X-Ray silhouette onto a detector
- Measures densities
- 3D maps to 2D
- Detectors often use an intervening fluorescent screen to convert X-rays to visible light
- Fat, muscle, bone, contrast agent, metal



5

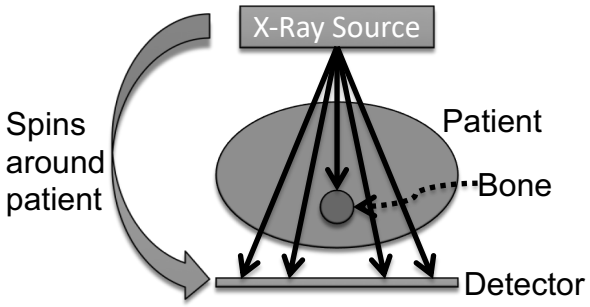
Computerized Tomography



Mikael Häggström's CT of the human brain with intravenous contrast

6

Computerized Tomography



- Spin X-Ray source/detector around the patient
- From a series of projections, a tomographic image is reconstructed using Filtered Back Projection.

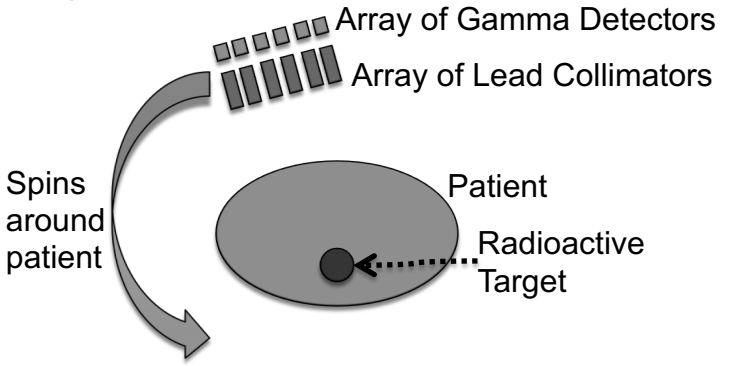
7

Nuclear Medicine

- Previously discussed imaging modalities image anatomy (structure).
- Nuclear medicine images physiology (function)
  - At the cellular (and subcellular) level
  - Technically a type of molecular imaging
  - Requires use of radioactive pharmaceuticals

8

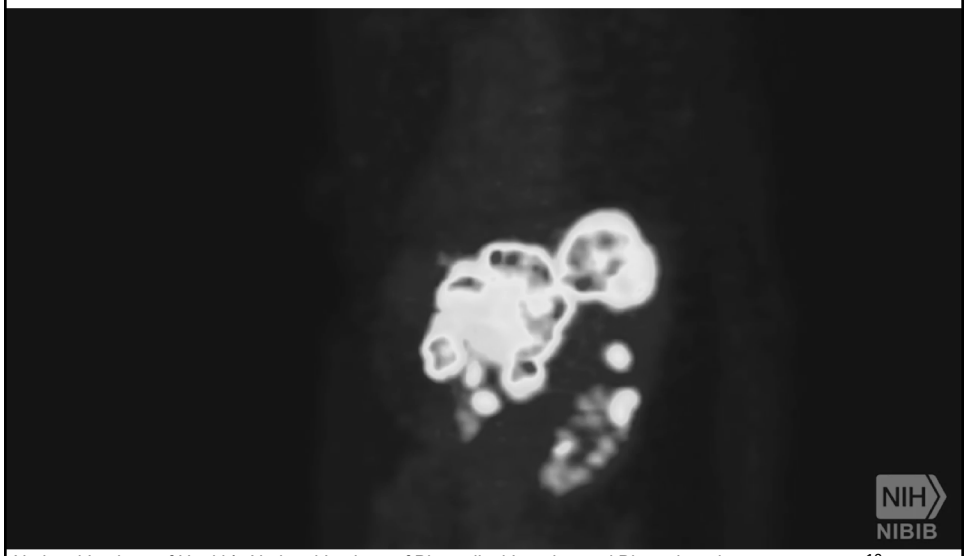
SPECT



- Single Photon Emission Computed Tomography
- Gamma camera for creating image of radioactive target
- Camera is rotated around patient

9

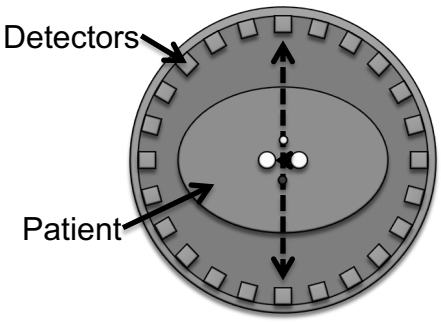
Positron Emission Tomography (PET)



National Institute of Health's National Institute of Biomedical Imaging and Bioengineering
60 Seconds of Science: How Does a PET Scan Work? CC By License; Music by Longzijun

10

Positron Emission Tomography

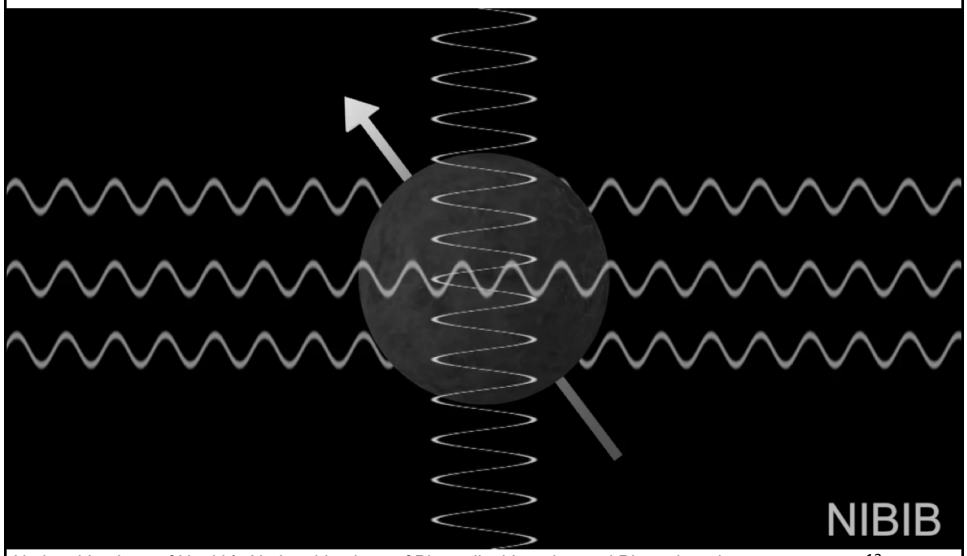


When emitted positrons collide with electrons, their annihilation sends 2 high-energy photons off in opposite directions

- Positron-emitting organic compounds create pairs of high energy photons that are detected synchronously.
- No collimators, greater sensitivity.
- Attenuation is not location dependent, so quantification is possible.

11

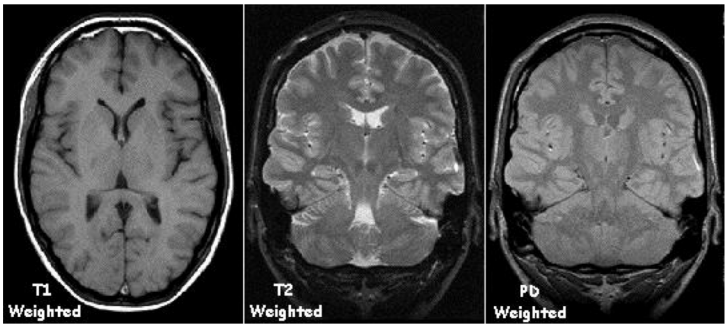
MRI



National Institute of Health's National Institute of Biomedical Imaging and Bioengineering
60 Seconds of Science: How Does an MRI Work? CC By License; Music by Longzijun

12

MRI

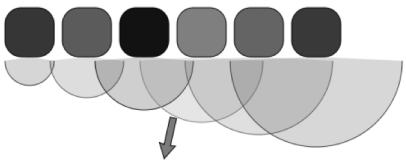


Kieran Maher's examples of T1 weighted, T2 weighted, and PD weighted MRI
T1: Bright = Short T1 = Tissue rapidly returns to pre-RF magnetization along z-axis
T2: Bright = Long T2 = Tissue maintains transverse (xy) magnetization long after RF pulse
PD: Proton Density, great for imaging joints, for brain T2-FLAIR is now more common
*-FLAIR: Long inversion time blocks signal from CSF in brain (CSF dark instead of bright)

See also: http://mriquestions.com/meaning-of-weighting.html

13

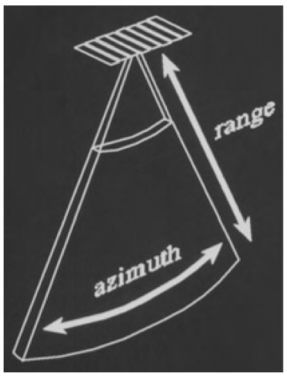
Phased Array Ultrasound

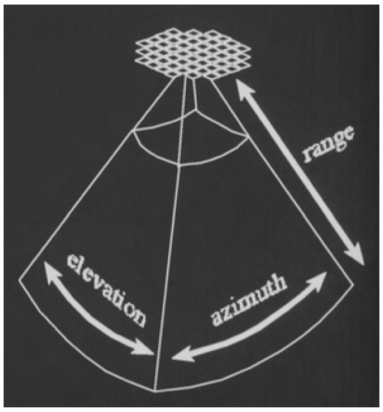


- Images anatomy
- Ultrasound beam formed and steered by controlling the delay between the elements of the transducer array

14

Real Time 3D Ultrasound





15

Other Imaging Modalities

- MRI & fMRI details (saved for another lecture)
- OCT (“optical ultrasound”)
- Pathology (in addition to Radiology)
- Other modalities coming down the pike

16

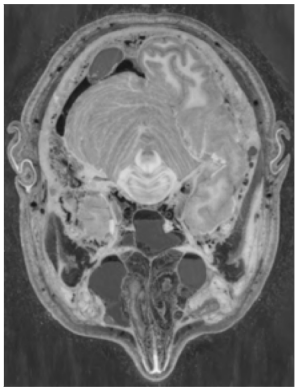
Current Trends in Imaging

- 3D, 4D, …
- Higher speed
- Greater resolution
- Measure function as well as structure
- Combining modalities (including direct vision)

17

The Gold Standard

- Dissection:
  - Medical School, Day 1: Meet the Cadaver.
  - From Vesalius to the Visible Human



18