Medical Imaging Modalities

Methods in Medical Image Analysis - Spring 2019
16-725 (CMU RI) : BioE 2630 (Pitt)
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Anatomical Axes

- Superior = head
- Inferior = feet
- Anterior = front
- Posterior = back
- Proximal = central
- Distal = peripheral
Imaging Modalities

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

1896: The X-Ray
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

Computerized Tomography

Mikael Häggström’s CT of the human brain with intravenous contrast
Computerized Tomography

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

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
SPECT

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

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Positron Emission Tomography (PET)
Positron Emission Tomography

- 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.

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

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 Longpizzun
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

Phased Array Ultrasound

- Images anatomy
- Ultrasound beam formed and steered by controlling the delay between the elements of the transducer array
Real Time 3D Ultrasound

Other Imaging Modalities

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

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

The Gold Standard

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