MRI = Magnetic Resonance Imaging

Imaging Modalities

- ?
- X-ray
- ?
- CT
- PET/SPECT
- ?
- Ultrasound

What is being measured?
How is it being measured?
Practical factors?
**Computed Tomography (CT)**

- **Source**
  - X-ray

- **Detector**

- **\( \mu(x, y, z) \)**
  - Attenuated

- **2D Image**

\[ \mu = \text{x-ray attenuation coefficient} \]

\[ f(\text{atomic number, electron density}) \]

\[ I_d = I_0 e^{-\mu d} \]
- **Line integral**

- **Computed tomography (CT)**

- **Source**
  - X-ray

- **Detector**

- **Slice**

- **Central Section Theorem**
  - Back-projection

Collect 1D projections at all angles can then reconstruct \( \mu(x, y) \)
Nuclear Medicine (SPECT/PER)

Uptake of radio-labelled material (loc based on biochemistry)
collimated or point-like cameras

Images of functional anatomy

First three involve ionizing radiation

Ultrasound

X-ray

Propagate pulse, receive reflections
velocity 1500 m/s in H2O
acoustic reflectivity
i.e. echo time maps to depth

† frequencies \(\rightarrow\) resolution
\(\rightarrow\) attenuation \(\sim (1 \text{ dB/cm}) / \text{MHz}^{1/2}\)
Magnetic Resonance (MR)

- radio frequency field
  - polarizes the sample, creates a resonance condition
  - \( B_0 \): polarizes the sample, creates a resonance condition
  - \( H = \text{hydrogen} \rightarrow \text{tiny magnetic dipole} \)

- gradient field \( G \)
  - spatial localization, encode signals
  - includes tissue properties that influence behavior
  - flow
  - etc...
Comparisons

Toxicity

- Ionizing radiation (C) appears safe
- Neutrons, potential projectiles, neutrons
  - Ha: time varying fields, induce currents
    \[ \frac{df}{dt} > 10 \text{T/s} \] - light strokes
    even higher - proprioceptive feedback
    even higher - cardiac stims
  - B, RF heating

Applicability

- Everywhere (no physical boundary) (X)
- Soft tissue / fund path (U)
- Everywhere, best in stationary region b/c long sun time
  not great for adults

Distortion

- No significant distortion. CT ATF near total attenuation (X)
- Refraction, refraction in \( \nabla \) affects depth estimate
  distortion \( k = \text{resolution} \) \( \to \) lateral distortion
  \( \nabla \) RF percutaneous effects \( \to \) intensity variation
  non-linear in B fields \( \to \) geometrical distortions
Physical Parameter

1. $\mu$ - linear x-ray attenuation coefficient
2. $R$ - acoustic reflectivity
3. $\rho$ - density of $^1H$
4. $T_1, T_2$ - tissue parameters

To be continued