

# Biomedical Imaging

## Conclusion

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# Course Topics

- Background Material
  - Wave Theory. Tissue Properties.
  - Absorption, Scattering, and Reflection
  - Contrast, Resolution, and penetration
- X-Ray, X-Ray CT
- MRI
- Inverse Problems
- Ultrasound
- Optics
  - Microscopy in the laboratory
  - *In-vivo* Microscopy
  - Optical Coherence Tomography
- Machine Learning in Imaging
- Endoscopy

# Common Themes

- Contrast
- Resolution  $(x,y,z,t)$
- Penetration
- Other Issues
  - Invasiveness
  - Equipment Cost
  - Reimbursement Issues
  - Size
  - Safety
  - Complexity
  - Speed
  - Many More ...

# Common Math: Waves

Waves  $\frac{\partial^2 ?}{\partial t^2} = c^2 \frac{\partial^2 ?}{\partial z^2}$  etc.



# Contrast

- Wave Speed (Index of Refraction)

$$\lambda\nu = c \quad (\nu = f)$$

- Scattering
- Absorption
- Albedo
- Emission
- Remember Ladder Diagrams

$$E = h\nu = \frac{hc}{\lambda}$$

- Spectral Dependence

# Resolution

- Wave Issues (Diffraction Limit)
  - Transverse:  $\lambda/NA$
  - Axial:  $\lambda/NA^2$
- Time of Flight  $2z = ct$
- Other: *e.g.* Field Gradient
- Sampling

# Penetration

- Absorption + Scattering = Extinction
- Spectral Dependence (Often Extinction  $\uparrow$  as Frequency  $\uparrow$ )
- Diffuse vs. Ballistic

- Tissue Model
  - Layers, Cylinders, Spheres, *etc.*
  - Size, Density, Locations
- Interaction Model
  - Contrast Parameters (*e.g.*  $\sigma_s, \sigma_a$ )
  - Wave Propagation Model (*e.g.*  $\mu_s, \mu_a$ )
  - Resolution
- Imaging Model
  - Time Gates, Scanning, *etc.*
  - A–scan, B–Scan, *etc.*
  - Noise, Speckle, *etc.*



# Inverse Problem

- Often a Simpler Model (Linear?)
  - Model Errors
  - Noise
  - A–Priori Knowledge
- Matrix Inversion or Other Algorithm
- Decision (ROC Curve?)
- Machine Learning or Other AI?

# Other Courses

- EECE4512, Biomedical Electronics — No Overlap
- EECE4646, Optics for Engineers — No Overlap
- EECE4648, Biomedical Optics — Less than 10% Overlap
- EECE5664, Biomedical Signal Processing — Complementary
- BioE????, Intro/Neurophotonics: Imaging & Interrogation
- BioE/ME/EECE4992, Directed Study — Great Followup
- Exchange Courses For UAndes Students
- Senior Thesis or Capstone
- MS Thesis

# Thanks

- You are always part of our extended “posse.”
- Ask questions anytime.
- Use and extend your network.
- Tell your friends about this program.
- Keep in Touch.