BME101 Introduction to Biomedical Engineering

Medical Imaging

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Outline

- What is Medical Imaging?
- History of Medical Imaging
- X-Ray Imaging (Projection vs Tomographic Images)
- Nuclear Source Imaging
- Ultrasonic Imaging
- Magnetic Resonance Imaging
- Other Modalities

What is Medical Imaging?

Medical Imaging is a collection of techniques that are developed to measure and display distribution of a physical property in living subjects, specifically in humans.

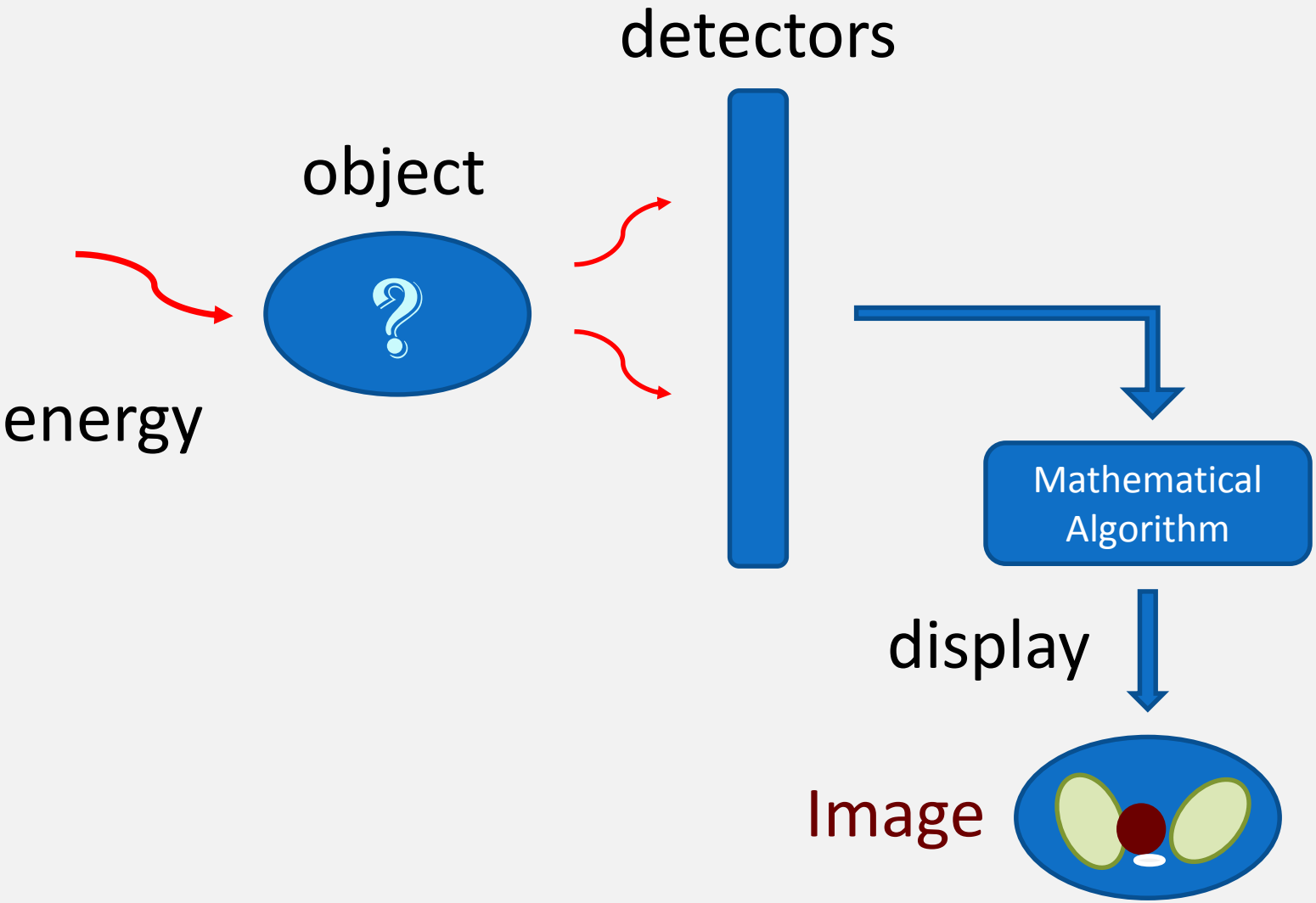
Medical Imaging provides information for diagnosis and monitoring of diseases.

Use of Different Imaging Modalities

All imaging modalities are based on the physics of the interaction of energy and matter.

Different imaging modalities are based on physical interaction of different enery types with biological tissues and thus provide images of different physical properties of tissues.

Basic Blocks of an Imaging System



Energy Types vs Physical Properties

Energy Types	Physical Properties
• X-Ray • Nuclear (radioisotopes) Sources • Ultrasonic Waves • Magnetic Fields • Mechanical Waves • Optical Waves • Electrical Current	• X-ray absorption coefficient • Radionuclide concentration • Ultrasonic properties • Spin density and spin relaxation • Mechanical Properties (elasticty etc) • Optical Properties (absorption, scattering etc.) • Electromagnetic properties (resistivity, permeability etc.)

Some Milestones in Medical Imaging

1895	• Discovery of X-Rays
1917	• Radon Transform
1946	• NMR Principles
1948	• Nuclear Medicine Scan
1952	• Ultrasound Imaging
1953	• Positron Tomography
1971	• Single Photon Emission CT
1972	• Development of X-Ray CT
1976	• NMR Imaging (MRI)

Structural vs Functional

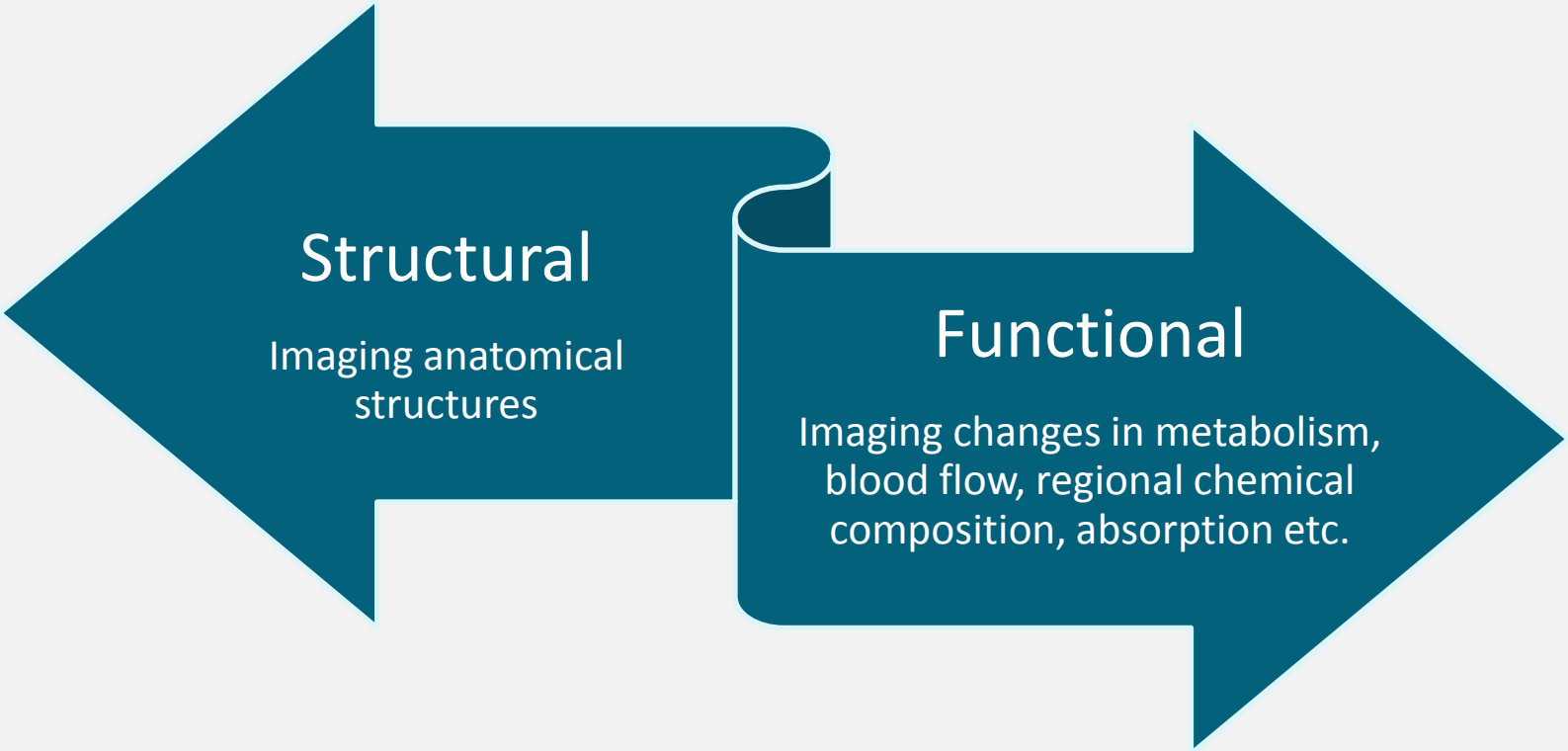


Image Resolution

Spatial Resolution

ability of differentiating two small objects placed closely

Contrast Resolution

ability of detecting the changes in the amplitude

Limits on Resolution

- Natural limits of the physical quantity used in imaging
- Limitations from the imaging hardware
- Noise sources
- Methods used in digitization of the image

X-Ray Imaging

Radiography

➡ Projection Imaging

(X-ray absorption coefficient)

CT

➡ Tomographic Imaging

(X-ray absorption coefficient)

Nuclear Source Imaging

- Radioisotopes (radionuclides) are injected to the body
- They emit radiation which can be detected by photon detectors and the position of the isotopes are detected

SPECT and PET

- SPECT (Single-photon emission computed tomography)

  single gamma ray is emitted per nuclear disintegration

- PET (Positron emission tomography)

  two gamma rays are emitted when a positron from a nuclear disintegration annihilates in tissue

Advantages/Disadvantages of Nuclear Source Imaging

- Functional images can be obtained
- Spatial resolution is poor
- Tissue specific contrast is good
- Involves ionizing radiation

Ultrasound Imaging

- The body is probed by an ultrasonic wave;
- The ultrasound wave propagates through the body;
- Some fraction of the ultrasound waves are reflected at various tissue interfaces along the wave path and echoes are produced;
- The reflected echo signlas are measured and used to reconstruct the reflection coefficient distribution along the path.

Advantages/Disadvantages of Ultrasound Imaging

- Functional images can be obtaines
- Involves no ionizing radiation
- Portable

Magnetic Resonance Imaging

- MRI uses magnetic fields and radio waves to form images of body

Advantages/Disadvantages of MRI

- Superior spatial resolution
- Good soft tissue contrast
- Functional imaging is possible
- Involves no ionizing radiation
- Relatively expensive
- Imaging time can be long for some scans

Other Modalities

- Electrical Impedance Tomography (EIT)
- Optical Imaging Techniques

  (Diffuse Optical Tomography, Bioluminescence Imaging, Fluorescence Imaging)
- Microwave Imaging
- Photoacoustic Imaging
- ….

Multi Modality Imaging

- Combining two imaging modality
  (PET-MR, PET-CT, MR-CT etc.)

- Sequential vs simultaneous

Related Courses in the Program

	Fall Semester	Spring Semester
Year 2	BME 201 Circuit Analysis BME 211 Electrical Circuits Lab.	BME 202 Electronics BME 212 Electronics Laboratory
Year 3	BME 311 Biomedical Instrumentation I BME 301 Signals and Systems	BME 312 Biomedical Instrumentation II BME 302 Medical Imaging BME 304 Electromagnetics (elec.) *BME 322 System Dynamics and Control* *EEE 316 Information System Architecture* *EEE 322 Communication Theory*
Year 4	BME 401 Physiological Control Systems (elec.) BME 403 Bioelectricity and Biomagnetics (elec.) *EEE 405 Numerical Computing and Symbolic Programming* *EEE 423 Digital Signal Processing*	BME 402 Biosignal and Medical Image Processing (elec.) *EEE 412 Introduction to Estimation*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