

Lecture 26 – Review

This lecture will cover:

- Fundamentals of medical imaging
- Summary of imaging modalities
 - imaging physics
 - Imaging techniques
 - Instrumentation
 - Imaging characteristics
 - Specific technologies
- Other contents

Fundamentals of medical imaging

- Diagnostic Test
- Image Acquisition
 - Data acquisition
 - Dynamic range and resolution
 - Sampling frequency and bandwidth
- Image Characteristics
 - Spatial resolution
 - Contrast
 - Noise
 - Image artifacts
- Image Processing
 - Basic image operation
 - Spatial operation
 - Image filtering

Summary of image modalities

- imaging physics
- Imaging techniques
- Instrumentation
- Imaging characteristics
- Specific technologies

Comparison of Imaging modalities

Imaging modalities	2D	3D	Other technology
X-ray	Planar radiography	CT	Angiography, fluoroscopy,
Nuclear medicine	Gamma camera	SPECT, PET/TOF PET	
MRI		MRI	fMRI
Ultrasound	B-mode, M-mode,	Multi-dimension arrays	Doppler ultrasound

Imaging Physics

➤ X-ray:

Differential absorption of X-rays by various tissues.

➤ Nuclear medicine:

Measure the concentration of radiotracer molecules which are involved in a metabolic process.

➤ MRI:

- Magnetic Resonance-stimulate transition between the energy levels;
- The induced voltage is proportional to the time rate of change of the magnetic flux
- Relaxation time

➤ Ultrasound imaging:

Detecting reflected energy from the boundaries between tissues with different acoustic and physical properties

Imaging techniques

➤ X-ray:

- Linear and mass attenuation coefficient
- Radon transform and filtered back-projection method

➤ Nuclear medicine:

Radioactive decay: α -, β -, γ -decay

➤ MRI:

- Gradient magnetic fields
- The K-space and image reconstruction
- Basic imaging sequences

➤ Ultrasound imaging:

A-, M- and B-mode; Doppler ultrasound

Instrumentation

➤ X-ray:

X-ray tube, filters, collimators, anti-Scatter grid, detectors(CR, DR, Photon counting detector),

➤ Nuclear medicine:

Radio tracer, Detector scintillation crystal, Photomultipliers tubes, Anger position network, Pulse height analyzer, Annihilation coincidence detection

➤ MRI:

Magnet, three magnetic field gradient coils, RF transmit and receive coil, electronic circuits to control the 3 components

➤ Ultrasound imaging:

Single element transducer, beam forming & steering, array transducer.

Imaging characteristics

- Signal-to-noise ratio;
- Resolution;
- Contrast-to-noise ratio;
- Artifacts;

Specific Technologies

- Contrast agents
- X-ray:
 - Angiography, mammography, fluoroscopy,
 - Digital X-ray Tomosynthesis, Dedicated scanners, Dual-source and dual-energy CT, Electron beam tomography
- Nuclear medicine:
 - Time-of-flight PET
- MRI:
 - Magnetic resonance angiography(TOF MRA), Positive/negative contrast agent, fMRI
- Ultrasound imaging:
 - Doppler ultrasound (pulse wave, phase shift, spectral Doppler)

Other contents

- Radiation protection
 - Radiation dose and measurement
 - Ionizing radiation biological effects
 - Fundamental principles of radiation protection
 - Methods of exposure control
 - Medical radiation protection
- Medical image computing and visualization