

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
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- 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

➤ Other imaging modalities

- Optical Imaging
- fNIRS