

Medical Images Analysis and Processing - 25642

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Course Introduction

- Course Information:
 - Type: Graduated
 - Credits: 3
 - Prerequisites: Digital Image Processing

Course Introduction

- Reference(s):

- *Insight into Images: Principles and Practice for Segmentation, Registration, and Image Analysis*, By: T. S. Yoo, 2004 (Hardcopy)
- *Biomedical Images Analysis*, by: R. M. Rangayya, 2004, eBook.
- *Some papers!*
- *DIP References!*

Course Introduction

- Evaluation:
 - Final: 40%
 - Homework: 20% (Mostly Simulation)
 - Research Project: (20+5)%
 - In depth paper (one) study (Simulation and Judgment)
 - Experiments on real data
 - Medical Software 15%

Course Introduction

■ Journals:

- IEEE Transaction on Medical Imaging (TMI), IEEE Press
- Medical Image Analysis, Elsevier.
- Computerized Medical Imaging and Graphics (CMIG)
- IEEE Transaction on Biomedical Engineering. (TBE)
- IEEE Transaction on Image Processing (IP)
- IEEE Transaction on Pattern Analysis and Machine Intelligence (PAMI), IEEE Press.
- Pattern Recognition, (Pergamon-Elsevier)
- Pattern Recognition Letters (Elsevier)

Course Introduction

- Course Contacts and Links:
 - URL: <http://ee.sharif.edu/~miap>
 - Course Lecture Notes
 - Course Email: sut.course@gmail.com
 - Electronic Homework submission (NOT .rar)!
 - Submission rule:
 - Subject: **MIAP***n:stdnum*
 - My emails: fatemizadeh@sharif.edu
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Course Introduction

■ Syllabus:

- Introduction to Medical Images/Imaging – Briefly
- Introduction to Digital Image Processing
- Segmentation (Intro to Classification ?)
- Enhancement/Denoising
- Registration
- Interpolation
- Medical Image Analysis Using PDE
- Multilodal Image Analysis
- Computer Aided Diagnosis (CAD) – Mostly Mammography
- Medical Image Analysis Software (your task!)

Medical Images Modalities

- What is a medical image:
 - A geometric distribution of a certain physical/physiological property(ies).
- Modalities
 - Several images from a certain region!

Medical Images Modalities

- Concepts:

- How to build images of internal organs of body, non-invasively.
- Image Modalities
- Pre-processing
- Post-Processing

Image Construction

- Goal:
 - Draw images of a certain physical property of subject anatomy.
 - Procedure in non-invasive.
 - Image Geometry:
 - Projection
 - Tomography

Image Modality

- Based on Interested Physical Property:
 - X-Ray (CT/Radiography)
 - MRI (Magnetic Resonance Imaging)
 - PET (Positron Emission Tomography)
 - US (Ultra Sound)
 - SPECT (Single Photon Emission CT)
 - EIT (Electrical Impedance Tomography)
 - Video and etc.

Pre-Processing

- Concepts:
 - Design optimum protocol for raw data acquisition.
 - Image reconstruction from raw data.
 - Noise and artifact reduction in raw data space.

Post-Processing

- Concepts:

- Noise and artifact reduction in image space.
- Enhance images in Regions of Interest.
- Image partitioning to meaningful regions.
- Computer Aided Diagnosis (CAD)
- Multimodality Image Fusion
- Virtual Reality (Virtual Surgery)

Medical Images Modalities

- Medical Images Categories:
 - Number of channel:
 - Single channel (Only one property is acquired): CT , PET, US
 - Multichannel (More than one property are acquired): MRI

Medical Images Modalities

- Medical Images Categories:
 - Characteristic:
 - Anatomical: Static distribution of a certain physical property, *Skeleton*.
 - Physiological/Functional: Functionality or Metabolism of organs, *Glucose consumption in brain*.

Medical Images Modalities

- Medical Images Categories:

- Geometry:

- Projective: A Straight line in the object will be mapped to a single point at images, *Conventional Radiography*.
 - Tomography: Cross section of object will be imaged, *Computerized Tomography*.

- Dimensionality:

- 2D
 - 3D

Medical Images Modalities

- Major Properties in Medical Images:
 - X-Ray Transmission
 - Ultrasound Waves Reflection
 - Radioactive annihilation
 - Spin Density and Relaxation Times
 - Optical (Non-Laser/Laser)
 - Electrical Conductance

Medical Images Modalities

■ X-Ray Transmission:

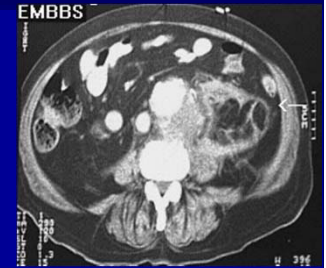
- Simple Physics: $I_T = I_0 e^{-\mu L}$
- Absorption coefficient (μ) of X-Ray photons (70-120Kev) are displayed as image.
- Projection and Tomography are possible.
- Hazard: Yes!
- Resolution: Very Good.
- SNR: Good.
- Almost Static (except for Fluoroscopy and rarely used fCT ,Functional CT.
- Good contrast for hard tissue (Bones)
- Low Contrast for soft tissue (Muscle, Tumors)

Medical Images Modalities

■ X-Ray Transmission:

– Examples:

- Conventional Radiography
- Computerized Tomography (CT)
- Angiography: Some organs like as blood vessels enhanced through injection of contrast agent
- Digital Subtraction Angiography (DSA): Difference of two images of a single organs in the different conditions (Before and after contrast agent injection or two different X-Ray energy) are displayed.
- Fluoroscopy: Watch oranges while the body is under X-Ray exposure.



Medical Images Modalities

- Ultrasound Wave Reflection:
 - Ultrasound Waves: Above 20KHz.
 - Reflection times of incident ultrasound beam are related to position of the walls.
 - Simple Physics: $x = ct$
 - Physical Characteristic in Tomography
 - Hazard: Low
 - Resolutions: Average (Different in two dimension)
 - SNR: Bad
 - Anatomical and Dynamic (Movements of objects) but not metabolism
 - Problem with objects behind bone and air (lung)
 - Need to access to the organs only from one side (Reflection)

Medical Images Modalities

- Ultrasound Wave Reflection:

- Examples:

- A-mode: 1D imaging, Eye's Layers.
 - B-mode (Sonography): 2D imaging, fetus, Bladder, kidney, Prostate .
 - C-mode: Tissue Characterization, Research Application.
 - Doppler/Color Doppler: Blood Flow and Heart (Valve and Cavity) Monitoring.



Medical Images Modalities

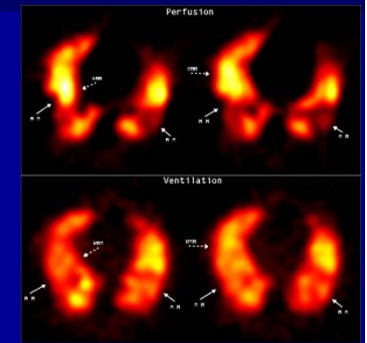
- Radioactive annihilation:
 - Source imaging: Source of radiation is located inside body (Injection , inhalation and etc.)
 - Source radiation (consumption) distribution are imaged.
 - Special Drug for each organs (I^{133} for Thyroid)
 - Projection and Tomography are possible
 - Hazard: Yes.
 - Resolution: Low.
 - SNR: Low.
 - Functional (Metabolism)

Medical Images Modalities

- Radioactive annihilation:

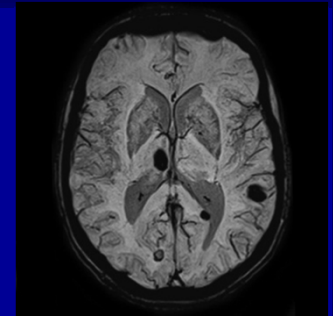
- Example:

- Gamma Camera: Projection Imaging
 - SPECT (Single Photon Emission Computerized Tomography): Tomography
 - PET (Positron Emission Tomography): Very interesting functional Imaging.



Medical Images Modalities

- Spin Density and Relaxation Times:
 - Based on Magnetic Resonance Properties.
 - Properties of Proton (H^+) spin are imaged.
 - Multichannel images:
 - PD (Proton Density)
 - T1: Spin-Lattice Relaxation Time.
 - T2: Spin-Spin Relaxation Time.
 - Data Acquisition is parametric:
 - Several Protocols for imaging are possible.
 - Projection and Tomography are possible.
 - Resolution: Good
 - SNR: Good
 - Hazard: Very Low (But banned for patients with ferromagnetic/Electrical/Magnetic Devices in their body)
 - High Contrast for soft tissue and Low for Hard tissue (bone)
 - Static and Functional, both.



Medical Images Modalities

- Spin Density and Relaxation Times:
 - Examples:
 - MRI: Magnetic Resonance Imaging, Brain Studies, Spin cord, Knee.
 - fMRI: Functional MRI, Blood flow, brain.
 - MRA: Magnetic Resonance Angiography, Vessel Studies.

Medical Images Modalities

- Optical:
 - Optical Reflection
 - Hazard: None (Patient Unconformity)
 - Resolution: High
 - SNR: High
 - Examples:
 - Endoscopy
 - Laryngoscopy
 - Colonoscopy
 - Optical Tomography found in research files

Medical Images Modalities

- Electrical Conductance:
 - Electrical Impedance Tomography (EIT)
 - Electrical Conductance (Resistance)
 - Low Resolution
 - Low SNR
 - Hazard: Electrical Safety Problem.
 - Low Price
 - Tomography

