Medical Images Analysis and Processing - 25642

EMAD FATEMIZADEH

DISTANCE/ONLINE COURSE: SESSION 01

DATE: 14 FEBRUARY 2021, 26TH BAHMAN 1399

Course Introduction

Course Information:

- Type: Graduated
- Credits: 3
- Prerequisites: **D**igital **S**ignal **P**rocessing

Course Introduction

- Reference(s):
  - ***Principles and Advanced Methods in Medical Imaging and Image Analysis***, A. P. Dhawan, H.K. Huang, and D. SH. Kim, 2008.
  - ***Biomedical Image Processing****, Thomas M. Deserno (Editor), Springer-Verlag, 2011.*
  - ***Medical Image Processing-Techniques and Applications****, G. Dougherty, Springer-Verlag, 2011.*
  - ***Advanced Biomedical Image Analysis****, M. A. Haidekker, Wiley, 2011.*
  - *Biomedical Images Analysis*, R. M. Rangayyan, 2005.
  - *Handbook of Biomedical Image Analysis* (3 Volumes), J. S. Suri, D. L. Wilson, and S. Laxaminarayan, 2005.
  - *Mathematical Models for Registration and Applications to Medical Imaging*, O. Scherzer, 2006.
  - *Medical Image Analysis Methods*, L. Costaridou, 2005.
  - *Insight into Images: Principles and Practice for Segmentation, Registration, and Image Analysis*, By: T. S. Yoo, 2004.
  - *Medical Image Processing, Reconstruction and Restoration: Concepts and Methods*, J. Jan, 2005.
  - 2-D and 3-D Image Registration for Medical, Remote Sensing, and Industrial Applications, A. A. Goshtasby, 2005.
  - *Medical Image Registration*, J. Hanjal, D. Hawkes, and D. Hill, 2001.
  - *Handbook of Medical Imaging – Processing and Analysis,* I. N. Bankman, 2000
  - *Pattern Recognition for Medical Imaging*, A. Meyer-Base, 2004.
  - *Image Processing Techniques for Tumor Detection*, M. Dekker.
  - **Top survey papers.**

Course Introduction

Evaluation:

- Exam #1 : 25% (Denoising)
- Exam #2 : 25% (Segmentation)
- Exam #3 : 25% (Registration and etc.)
- Homework: 15% (Mostly Simulation)
- Research Project: 10%
  - In depth paper Study (Simulation and Judgment)

Course Introduction

Related 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:

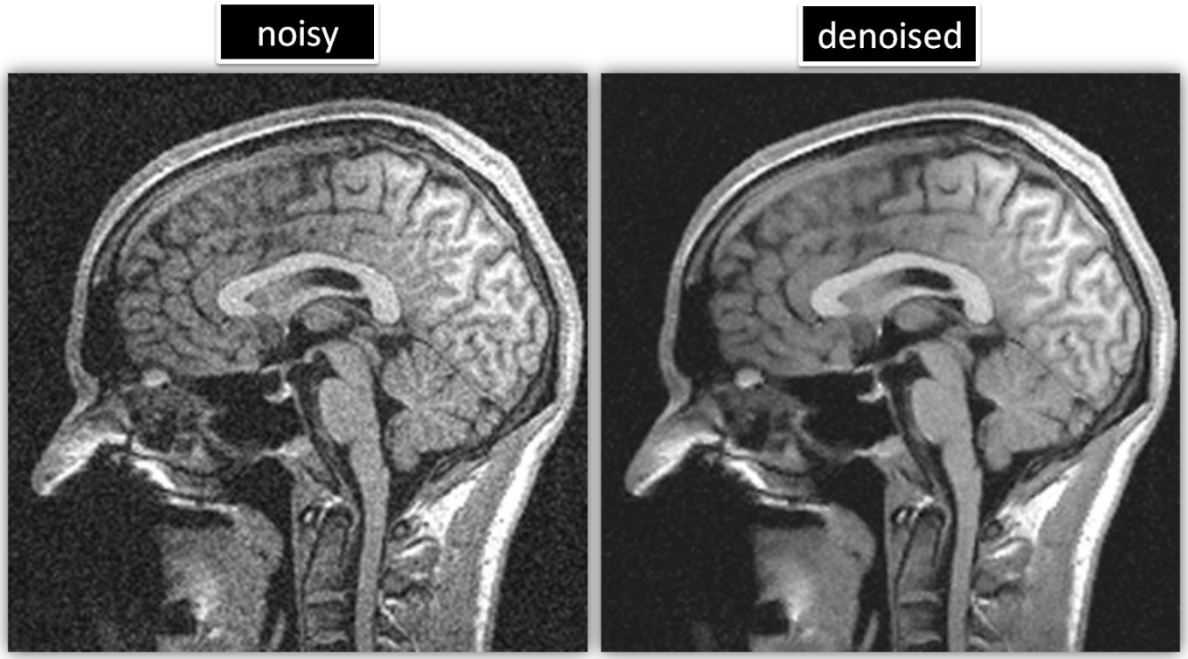
- WhatsApp Channel: https://chat.whatsapp.com/EMS5WtBOZ152gK2Eg5D5iq
- Sharif Courseware: **http:/cw.sharif.edu**
  - Course Lecture Notes
  - Course Video
  - HomeWorks
  -  Update your email in CW and EDU
- My emails: **fatemizadeh@{sharif.edu, gmail.com}**

Course Introduction

Syllabus:

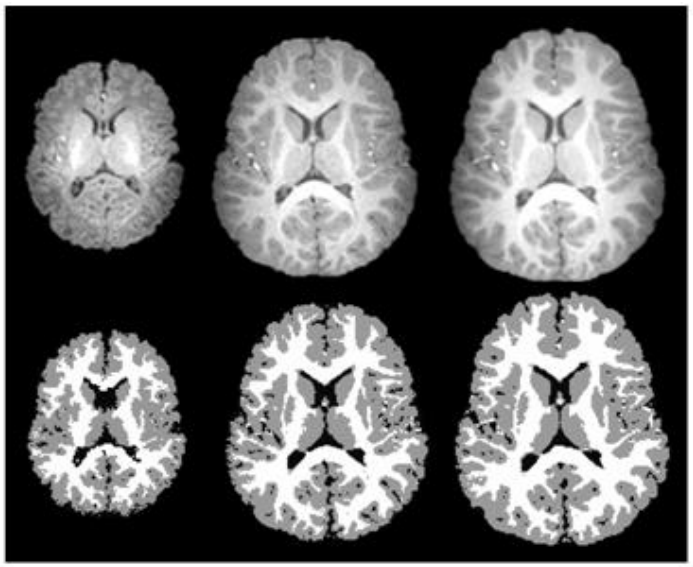
- Introduction to Medical Images/Imaging – Briefly
- Introduction to Digital Image Processing
- Enhancement Denoising
- Segmentation (Intro to Classification)
- Abnormality Extraction-Detection (Mammography)
- Registration
- Landmarks Extraction
- Interpolation
- Compression

Image Denoising



http://www.cs.utah.edu/~suyash/pubs/denoising_mri/

Medical Image Segmentation



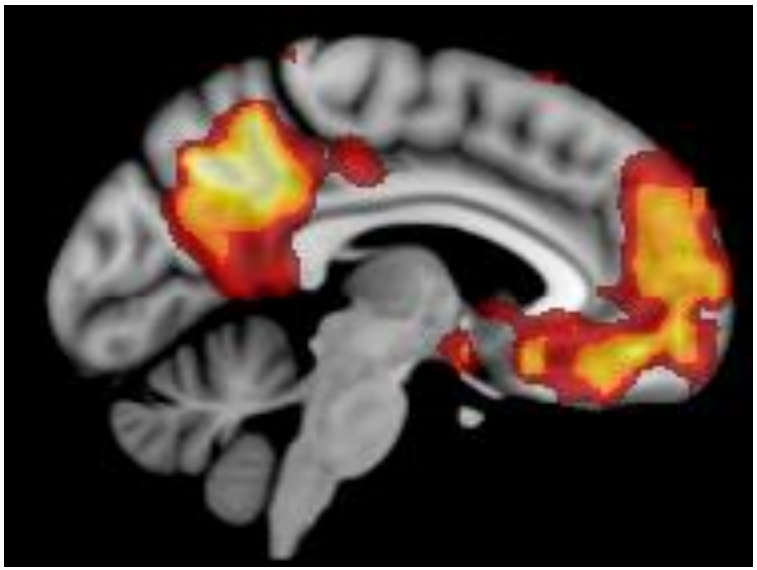
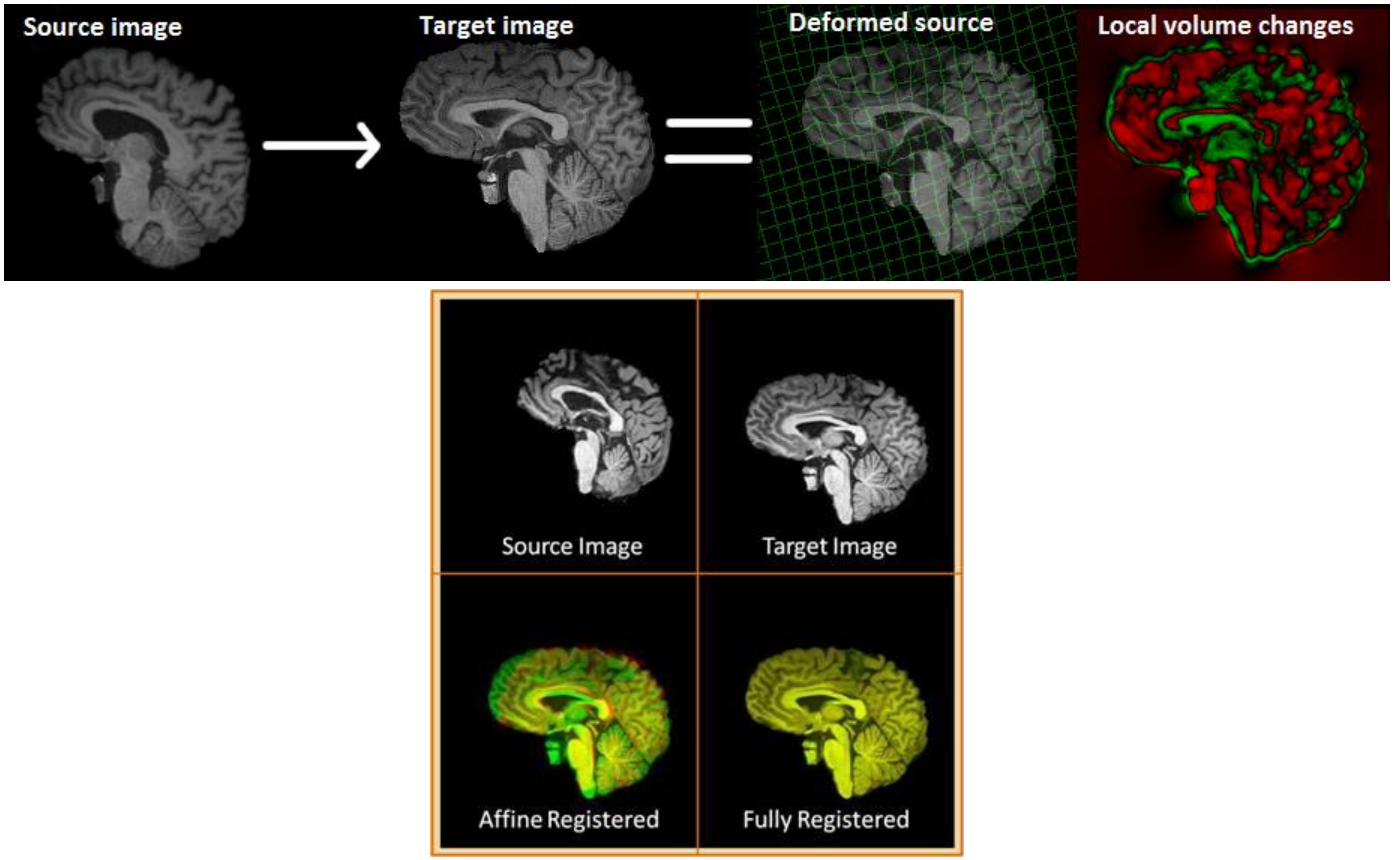


Image Registration



Medical Images Modalities

What is a medical image:

- A geometric distribution of a certain physical or 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 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)
- Image Registration and 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:
  - **Structural**: Static distribution of a certain physical property, *Skeleton, brain tissues*.
  - **Functional**: Functionality or Metabolism of organs, *Glucose consumption in brain*.

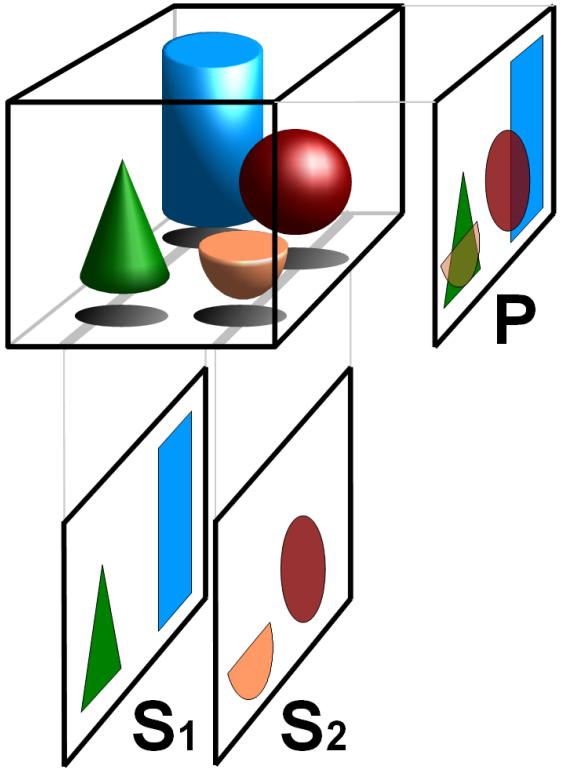
Medical Images Modalities

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 Image Geometry

Tomography vs. Projection



http://en.wikipedia.org/wiki/File:TomographyPrinciple_Illustration.png

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 Structural (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
- Structural 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:

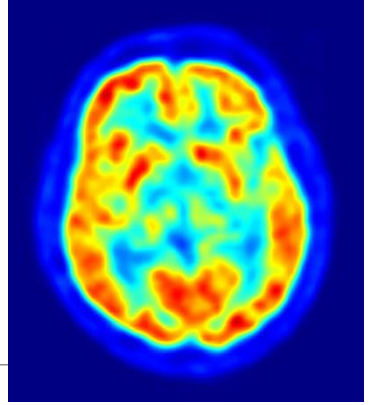
- Examples:
  - A-mode: 1D imaging, Eye's Layers.
  - B-mode (Sonography): 2D imaging, fetus, Bladder, kidney, Prostate .
  - C-mode: Tissue Characterization, Research Application.
  - Doppler/Color Doppler: Blood Flow and Heart (Valve and Cavity) Monitoring.

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)
- Structural and Functional, both.

Medical Images Modalities

Spin Density and Relaxation Times:

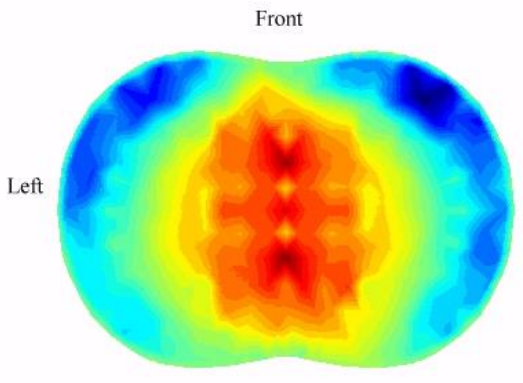
- Examples:
  - MRI: Magnetic Resonance Imaging, Brain Studies, Spin cord, Knee.
  - fMRI: Functional MRI, Blood flow, brain.
  - MRA: Magnetic Resonance Angiography, Vessel Studies.

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) is imaged.
- Low Resolution
- Low SNR
- Hazard: Electrical Safety Problem.
- Low Price
- Tomography

New and ongoing

OCT: Optical Coherence Tomography

PA: Photo Acoustics

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