Introduction to Medical Informatics

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Outline

• Medical Informatics
• Imaging Modalities
  • Computed Tomography
• Medical Imaging
• Content-based Image Retrieval for Medical Applications
What is Medical Informatics?

Simplistic definition:

Medical informatics is the application of computers, communications and information technology and systems to all fields of medicine - medical care, medical education and medical research.

*MF Collen, MEDINFO '80, Tokyo*
What is Medical Informatics?

Medical Informatics is the branch of science concerned with the use of computers and communication technology to acquire, store, analyze, communicate, and display medical information and knowledge to facilitate understanding and improve the accuracy, timeliness, and reliability of decision-making.

Warner, Sorenson and Bouhaddou, Knowledge Engineering in Health Informatics, 1997
Subdomains of Medical Informatics (by Wikipedia)

- imaging informatics

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Our Research

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Imaging Informatics

The Imaging Informatics Section is the computing arm of the Department of Radiology. As such, we have three primary missions:

1. We provide technical and operational support to the Northwestern Memorial Hospital (NMH) Picture Archiving and Communication System (PACS) and the NMH PACS team. We also provide research imaging services to the Northwestern PACS user community.

2. We support the computing needs of the faculty radiologists, their staff and the residents. This includes desktop computer and network support. We also provide FTP, e-mail, internal and external Web servers, and research DICOM image archive services.

3. We operate the Imaging Informatics research laboratory. The laboratory is a 4000 square foot facility, fully equipped for imaging informatics research. We operate a large UNIX server as well as several Windows 2000 and Windows NT servers. We also operate two PACS test environments that emulate the c
What is Medical Imaging?

The study of *medical imaging* is concerned with the interaction of all forms of radiation with tissue and the development of appropriate technology to extract clinically useful information (usually displayed in an image format) from observation of this technology.

**Sources of Images:**

- **Structural/anatomical information** (CT, MRI, US, VH) - within each elemental volume, tissue-differentiating properties are measured.
- **Information about function** (PET, SPECT, fMRI).
Examples of Medical Images

- X-ray Image of the hand
- Computed Tomography (CT) Image of a plane through liver and stomach
- Functional Magnetic Resonance Imaging (fMRI) of the brain
- Ultrasound image of a woman’s abdomen
- Single Photon Computed Tomography of the heart
- Fluorescence Microscopy: Image of living tissue culture cells.
What is a Medical Image?

- pixel
- slice thickness
DICOM standard in Medical Imaging

DICOM: "Digital Imaging and Communication in Medicine"

The DICOM Standard allows to get pixel data for each produced image and to associate specific information to them:

- name of the patient,
- type of examination, hospital,
- date of examination,
- type of acquisition etc...
Major Advances in Medical Imaging

- Image Segmentation
- Image Classification
- Content-based Image Retrieval
- Image Annotation

These major advances can play a major role in *early detection, diagnosis, and computerized treatment planning in cancer radiation therapy.*
Image Segmentation: Example 1

Gray-level histogram thresholding for lung segmentation
Image Segmentation: Example 2

Nodule segmentation

Extracted nodule regions by the automated nodule segmentation
Content-based medical image retrieval (CBMS) systems

Definition of Content-based Image Retrieval:

Content-based image retrieval is a technique for retrieving images on the basis of automatically derived image features such as texture and shape.

Applications of Content-based Image Retrieval:

• Teaching
• Research
• Diagnosis
• PACS and Electronic Patient Records
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Diagram of a CBIR

Image Database

Feature Extraction

Image Features

[\{D_1, D_2, \ldots, D_n\}]

Similarity Retrieval

Query Image

Feedback Algorithm

User Evaluation

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http://viper.unige.ch/~muellerh/demoCLEFmed/index.php
Content-based image retrieval as a diagnostic aid with use of medGift and the casimage database. The query image (left) shows emphysematous lesions with multiple confluent centrilobular and paraseptal areas of low attenuation without visible walls. The search results show six images, including five cases of emphysema (right), with each image accompanied by a link to the complete case description. One image demonstrates unilateral emphysema (MacLeod [Swyer-James] syndrome), and two images show a small area of consolidation in the pulmonary parenchyma (cryptogenic organized pneumonia [COP] and pulmonary embolism). The typical pattern of pulmonary parenchyma destruction seen on these five images strongly suggests the diagnosis of emphysema for the query image.
Evaluation & Interpretation

- **Sensitivity**: the ratio between true positives and total positives
- **Specificity**: the ratio between true negatives and total negatives
- Receiver Operator Characteristic (ROC)

A *true positive* is an abnormality classified as malignant when it is actually malignant.

A *true negative* is an abnormality classified as benign when it is actually benign.
Medical Imaging Research Groups

- University of Chicago, Northwestern University, Iowa University, University of California at Los Angeles, University of Michigan, and many others
- DePaul University, CTI:
  - Minor in Visual Computing for undergraduates
  - Computer Vision area – CS graduate program

Website: http://facweb.cs.depaul.edu/research/vc/
Medical Imaging Funding Resources

• **Federal agencies:**
  - NIH - *National Institutes of Health*
  - NSF – National Science Foundation

• **Industries:**
  - GE Medical Systems
  - Toshiba
  - Siemens
  - Philips
Medical Imaging Professional Societies

- **SPIE-Medical Imaging** - *The Society of Photo-Optical Instrumentation Engineers.*
- **SCAR** - *The Society for Computer Applications in Radiology* focuses on digital imaging and issues arising out of it.
- **RSNA** - *The Radiological Society of North America* represents clinicians.
- **HIMSS** - *the Healthcare Information and Management Systems Society* focuses on more global enterprise communication issues with which digital imaging and PACS must be integrated.
Questions?