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# Image Retrieval in Radiology: The ImageCLEF Challenge

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## Learning Objectives

- Introduce content-based image retrieval
- Provide an overview of the ImageCLEF challenge
- Describe applications of ImageCLEF's results to radiology

## Medical Image Retrieval

- Why image retrieval?
  - Select cases from teaching files
  - Retrieve visually similar cases for clinical decision making
- Applications
  - Image search engines
  - Teaching files
  - Quality improvement

## Image Retrieval Approaches

- Text-based
  - Uses textual annotations associated with images
- Visual or content-based
  - Uses image features
    - color
    - texture
    - shape
    - segmentation

## Text-based Image Retrieval

- Uses textual annotations or captions associated with the images
- Two approaches
  - Keywords – matches specific text words
  - Concepts – matches to concepts discovered in the text

## Keyword-based Retrieval

- Searches for matching words in an image's textual caption

**"kidney"**


"... 34-year-old woman with medullary sponge **kidney**, renal colic, and hematuria ...


"... Frontal view of the right **kidney** obtained during excretory urography ..."


"Normal-sized right **kidney** with focal areas ..."

## Concept-based Retrieval

- Retrieves images based on associated medical concepts

**Bone Tumor**

"**Enchondroma**. Radiograph of 52-year-old man ...

"**Brown tumors** of hyperparathyroidism. ... "

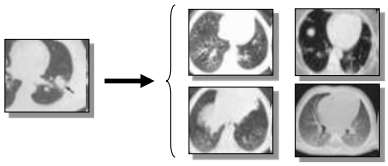
"8-year-old girl with **Ewing's sarcoma** of pelvis. ...."

## Image Content-based Retrieval

- "Visual" image retrieval
- Uses image processing techniques to extract image features
  - Color
  - Texture
  - Shape
  - Segmentation

## Content-based Retrieval

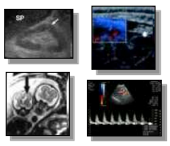
- Match a target image
  - Given an image as "input," find visually similar images



## Content-based Retrieval

- Select images of a specified modality
  - Use information in the image
    - e.g., color, texture
  - Match to images with known imaging modality

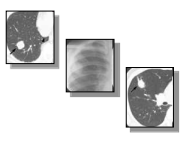
**Ultrasound** →



## Content-based Retrieval

- Find images that contain specific features

**Lung Nodule** →



## CLEF

- Cross Language Evaluation Forum
  - International participation
  - Seeks to overcome language barriers in information retrieval
- **www.clef-campaign.org**

## CLEF

"The Cross-Language Evaluation Forum promotes R&D in multilingual information access by:

- Developing an **infrastructure for testing, tuning and evaluation** of information retrieval systems operating on European languages in both monolingual and cross-language contexts, and
- Creating **test-suites** of reusable data which can be employed by system developers for benchmarking purposes."

## ImageCLEF

- Cross-language **image** retrieval
  - Evaluates retrieval of images described by text captions based on queries in a different language
  - Both text and image matching techniques may be used
  - Includes medical image retrieval and annotation challenges
- Part of CLEF
  - Cross Language Evaluation Forum campaign


**www.imageclef.org**

## ImageCLEFmed 2009

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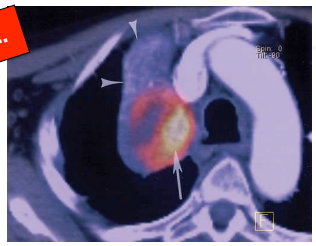
- Participants: 17 groups submitted 124 runs
  - from nine countries, four continents
- including . . .
  - UIIP Minsk (Belarus)
  - York University (Canada)
  - NIH / National Library of Medicine (USA)
  - Oregon Health and Science University (USA)
  - DEU (Turkey)
  - University of Geneva (Switzerland)
  - ISSR (Egypt)

## 2010 Image Database

- 77,495 images
  - From *Radiology* and *RadioGraphics*
    - Made available courtesy of RSNA
    - Subset of the ARRS GoldMiner® image database
- For each image, figure caption was supplied as free text
  - All text in English

**Figure 20. Large cell lung cancer in a 54-year-old woman.**

For example …



Axial fused FDG PET-CT image shows hypermetabolism within a lung mass (arrow) and distal drowned lung (arrowheads). Precise localization of a tumor within a larger mass helps direct intervention such as biopsy.

**Kapoor, V. et al. Radiographics 2004;24:523-543**


RadioGraphics

## Query Topics

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- Realistic topics were provided in
  - English
  - French
  - German
- 25 Ad-hoc and 5 case-based topics
  - Ad-hoc topics were classified as
    - Visual
    - Mixed
    - Semantic or Textual
  - Case-based topics were introduced in 2009

## Ad-hoc Query Topics

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- Search topics were identified by surveying actual user needs.
- Google grant funded user study conducted at OHSU in 2009
  - Qualitative study conducted with 37 medical practitioners
  - Participants performed a total of 95 searches using textual queries in English.
- Randomly selected 25 candidate queries from the 95 searches to create the topics for ImageCLEFmed 2009

## Ad-hoc Query Topics

Show me photographs of benign or malignant skin lesions.
Zeige mir Bilder von gutartigen oder bösartigen Hautläsionen.
Montre-moi des images de lésions de la peau bénignes ou malignes.

Show me images of right middle lobe pneumonia.
Zeige mir Bilder einer Lungenentzündung des rechten mittleren Lungenlappens.
Montre-moi des images d'une pneumonie du lobe médial droit.

Hersh WR, et al. JAMIA 2006.

## Case-based Topics

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- Scenario: provide clinician with articles from the literature are similar to the case (s)he is working on
- Five topics were created based on cases from the teaching file Casimage.
  - The diagnosis and all information about the treatment was removed
  - In order to make the judging more consistent, the relevance judges were provided with the original diagnosis

## Case-based Topics

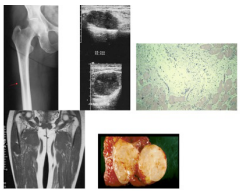
A 63 year old female remarked an unpainful mass on the lateral side of her right thigh. Five months later she visited her physician because of the persistence of the mass. Clinically, the mass is hard and seems to be adherent to deep planes.

XR : there is slight thinning, difficult to perceive, of the outer cortex of the right femur of approximately 3-4 cm in length, situated at the junction of the upper and middle third, without periosteal reaction or soft tissue calcifications.

US : demonstrates a 6x4x3cm intramuscular mass of the vastus lateralis. This mass is well delineated, hypoechoic, contains some internal echoes and shows posterior enhanced transmission.

MRI : The intramuscular mass of the vastus lateralis is in contact with the femoral cortex. There is thinning of the cortex but no intramedullary invasion

Diagnosis: **Myxoma**



## Query Topics

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- Each topic covered one or more of the following axes:
  - Anatomic region shown in the image
  - Image modality (*e.g.,* xray, CT, gross pathology)
  - View (*e.g.,* frontal, sagittal)
  - Pathology or disease shown in the image
  - Abnormal visual observation (*e.g.,* enlarged heart).

## Query Topics: Examples

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- Photos of erythema (visual)
- MR Images of rotator cuff (visual)
- Granuloma CT (mixed)
- Ultrasound of tubo-ovarian abscess (mixed)
- Pneumoconiosis (textual)
- Pituitary adenoma (textual)

## Types of Searches

- Manual
  - Topics translated manually into search queries
- "Interactive"
  - Users allowed to revise search criteria based on results
- Automatic
  - All steps done automatically
    - Parsing the query
    - Executing the query
    - Analyzing the results

## Information Used

- Visual
  - Image data only
- Textual
  - Text (figure captions) only
- Mixed
  - Both images and text

## Measuring Results

- In response to a ***query***, an information retrieval (IR) system searches its document collection and returns a ordered list of responses, called the **retrieved set**
- The relevance of the results to the query are measured as **recall** and **precision**

## Info Retrieval Metrics

- Recall
  - Fraction of relevant results that are retrieved
  - Analogous to positive predictive value (PPV)
- Precision
  - Fraction of retrieved results that are relevant
  - Analogous to specificity

## Info Retrieval Metrics -- cont.

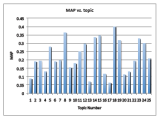
- Average Precision
  - Average of precision values computed after truncating the list after each relevant document
  - Emphasizes returning more relevant documents "higher" on the retrieval list

## Info Retrieval Metrics -- cont.

- Mean Average Precision (MAP)
  - The most frequently used summary measure of a ranked retrieval
  - Given a set of queries, MAP is the mean of the average precision values for each query

## Results

- Easy Topics
  - CT Images of an inguinal hernia
  - Lobar pneumonia x-ray
  - Glioblastoma multiforme MR
  - Pneumoconiosis
- Difficult Topics
  - Mesothelioma image lung disease
  - Gross or micro pathology
  - Gallbladder histology



## Inter-rater agreement

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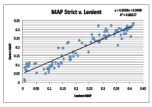
- 16 of 30 topics had multiple judges
  - Some judges overly lenient
    - not used for final qrels
  - Familiarity with topic seems to impact leniency
    - Experts seem to require more precise results
- Correlation of measures with different judges depends on their level of leniency



## Results

- Performance varied widely among topics
  - Some topics were better suited to this set of images and captions
  - The textual captions contained much of the useful information
  - The purely image-based approaches did less well

## Applications

- Textual information – such as figure captions – is highly useful for retrieving relevant medical images
- Techniques evaluated at ImageCLEF can be used to improve image search engines
  - Visual (content-based) retrieval methods will incorporated into ARRS GoldMiner® to improve classification of images by imaging modality

## Summary

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- Medical images can be retrieved using their contents (e.g., a visual exemplar) and/or textual metadata.
- ImageCLEF defines robust, standardized test collections of images and realistic query tasks to evaluate multilingual image retrieval.
- The ImageCLEF 2010 challenge featured more than 77,000 images from *Radiology* and *RadioGraphics*.
- Lessons learned can help improve radiology image retrieval.

## For more information . . .

- ImageCLEF 2010
  - **www.imageclef.org**
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