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Topics of Research:

- Medical Image Analysis
- Content-Based Image Retrieval in Medical Archives
- Segmentation, Tissue characterization, Lesion Detection
- Brain MRI, Cervical Cancer research, Echo-Doppler…

Some GAPS in Medical CBIR
When IMAGES are part of the CONTENT

- Retrieving based on Image Landmarks
  From the Task to the Reality - An example
- Image 2 Image Retrieval
  What is a good image representation space?
  Defining image similarity measures
- ROI based Retrieval

Initial steps towards Content Based Indexing and Retrieval of Cervigrams

- Cervical cancer - the second most common cancer for women worldwide; the most common in developing countries.
  Annually: 400,000 new cases of invasive cervical cancer.

- Cervicography - cervical cancer screening using visual inspection of Cervigrams; testing based on color change of cervix tissues when explosed to acetic acid. Inexpensive, suitable for third world countries

Cervigram

Neck of the uterus is photographed with a special 35 mm camera with a ring flash

Data

National Cancer Institute (NCI)

100,000 cervicographic images.
Medical classifications for the Cervigrams into diagnostic categories

<u>Example query:</u>
"find all images where the regions of type 1 entail at least 0.1% of the total image area"

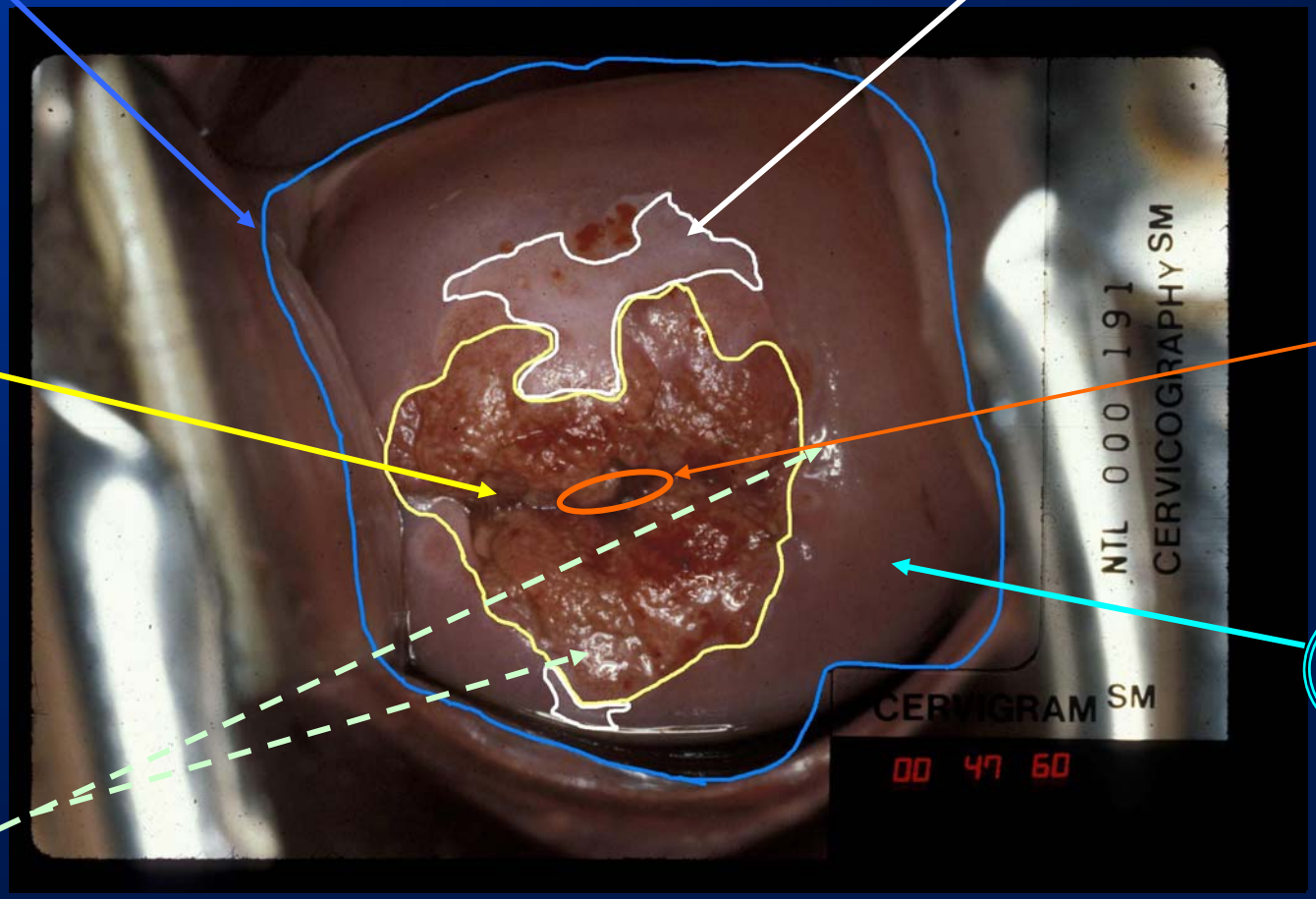
- Parameter extraction per tissue (size, color-texture specifications)

Goal

National Library of Medicine (NLM)

Web-Based database (PACS) of digitized cervix images

Cervigram Characteristics



Cervix Boundary

Aceto-White

CE

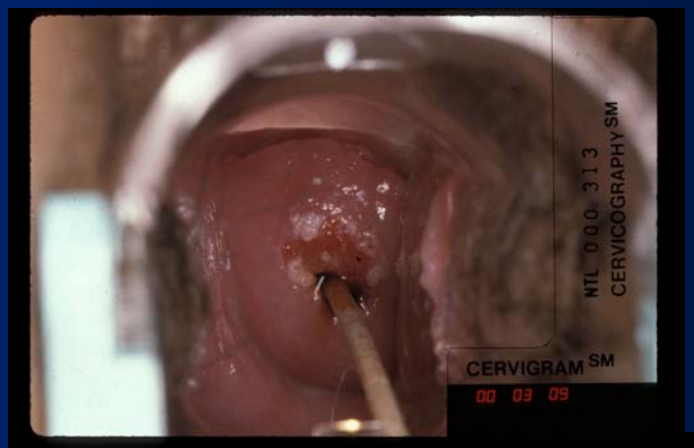
Os

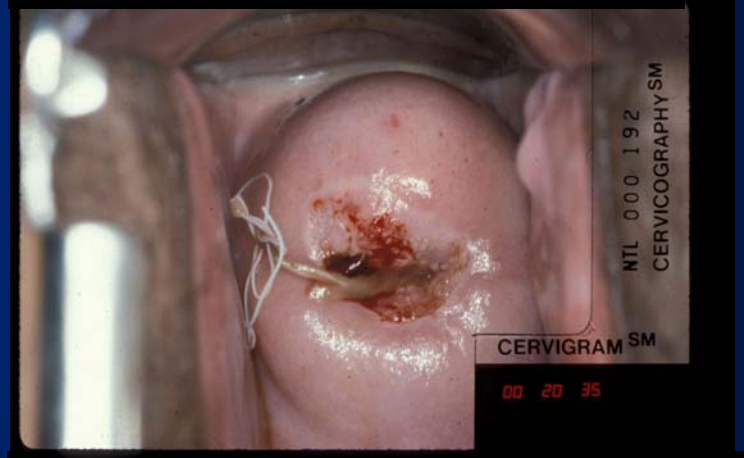
SE

Specular Reflections

Analysis Challenges

- Acquisition setup: different angles and illumination.
- Differences in visual appearance between patients
- Narrow dynamic range, lack of clear boundaries between tissues.





Automated Landmark Extraction & Cervigram Analysis

Coarse Region-of-Interest (ROI) Identification

Specular-Reflections (SR) Elimination

Cervix Boundary Detection

Os Detection

Illumination Correction and Intensity Normalization

Tissues Segmentation

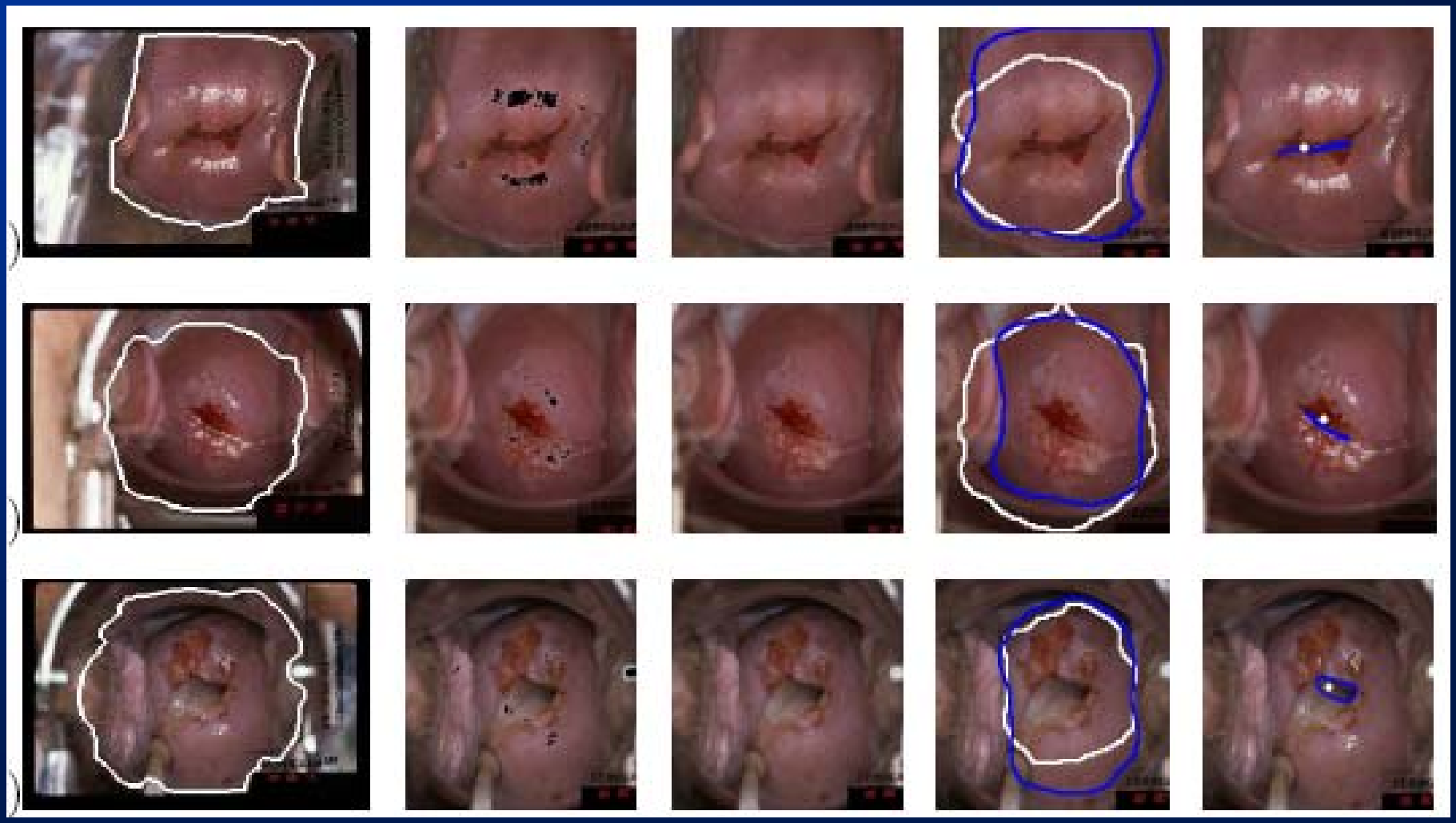
Analysis Tools:

Clustering

GMM Statistical modeling

Active contours

Landmark Detection Results

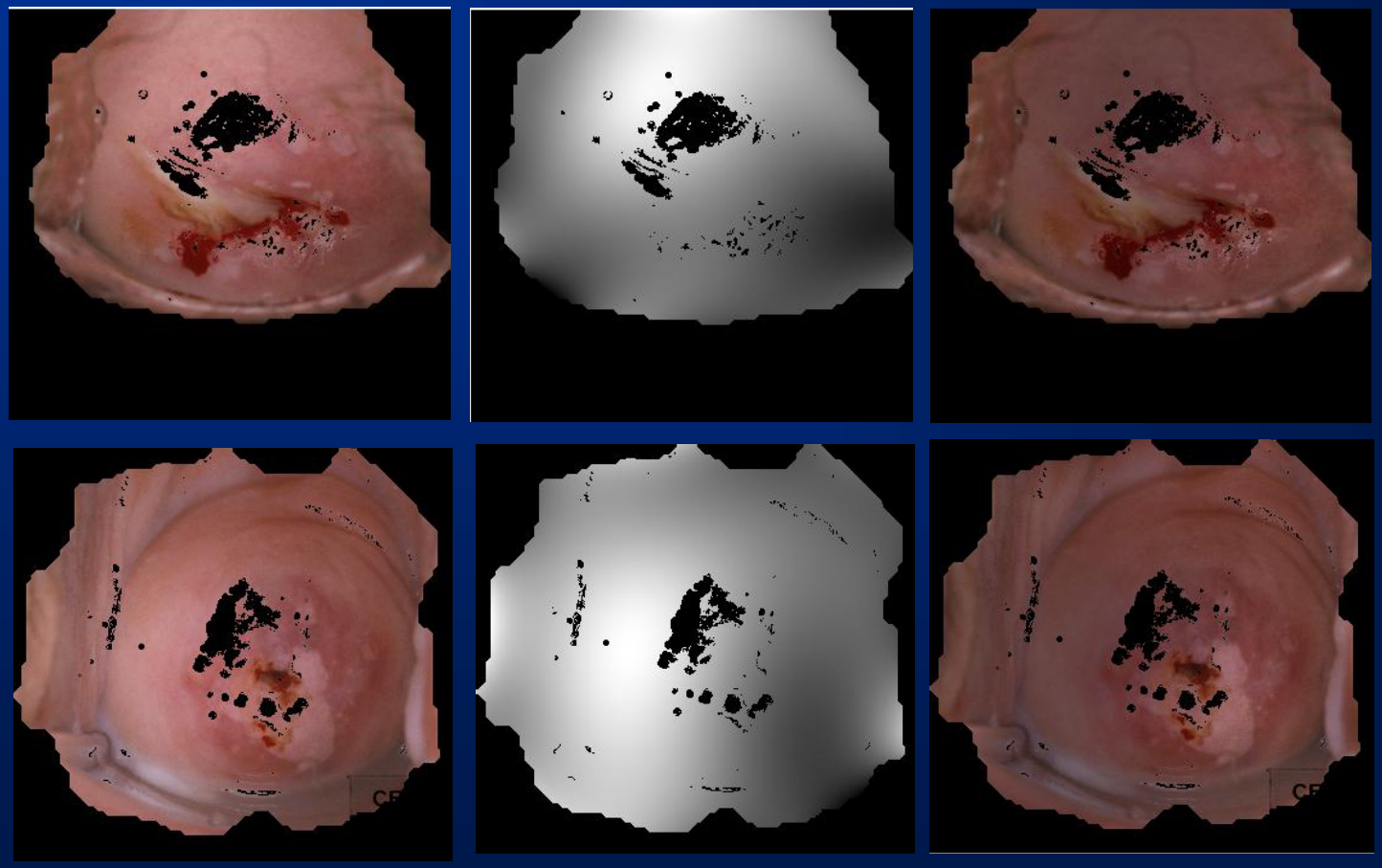


Original cervigram | SR detection | SR filling | Cervix boundary | Os

Progressing towards tissue categorization:

Illumination Correction & Intensity Normalization

[H. Dvir, S. Gordon and H. Greenspan, *IEEE WS MMBIA*, *CVPR*, 2006]

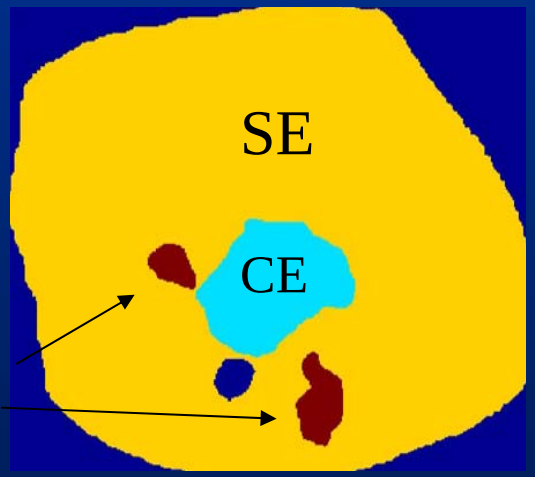


Illumination Field

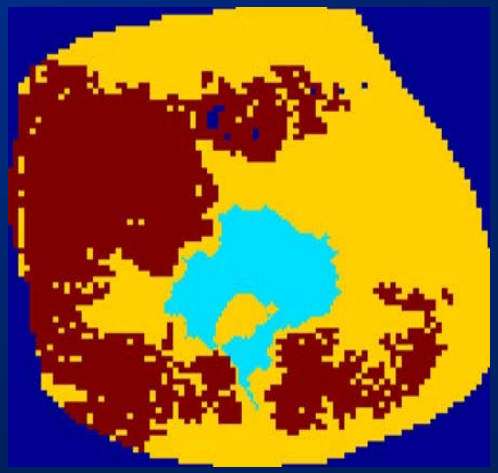
Illumination Corrected Image

Tissue Segmentation

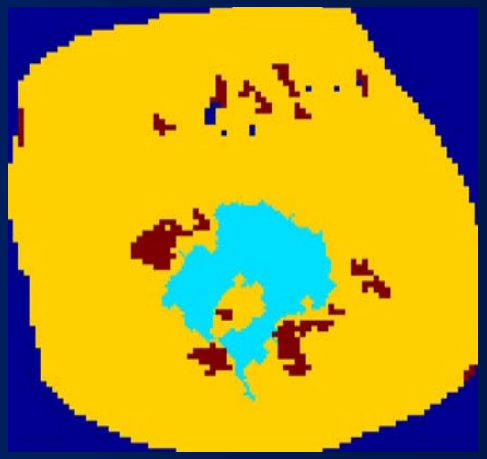
- Automated clustering into 3 categories: SE, CE, AW
- Pixel-wise probabilistic segmentation



Expert segmentation

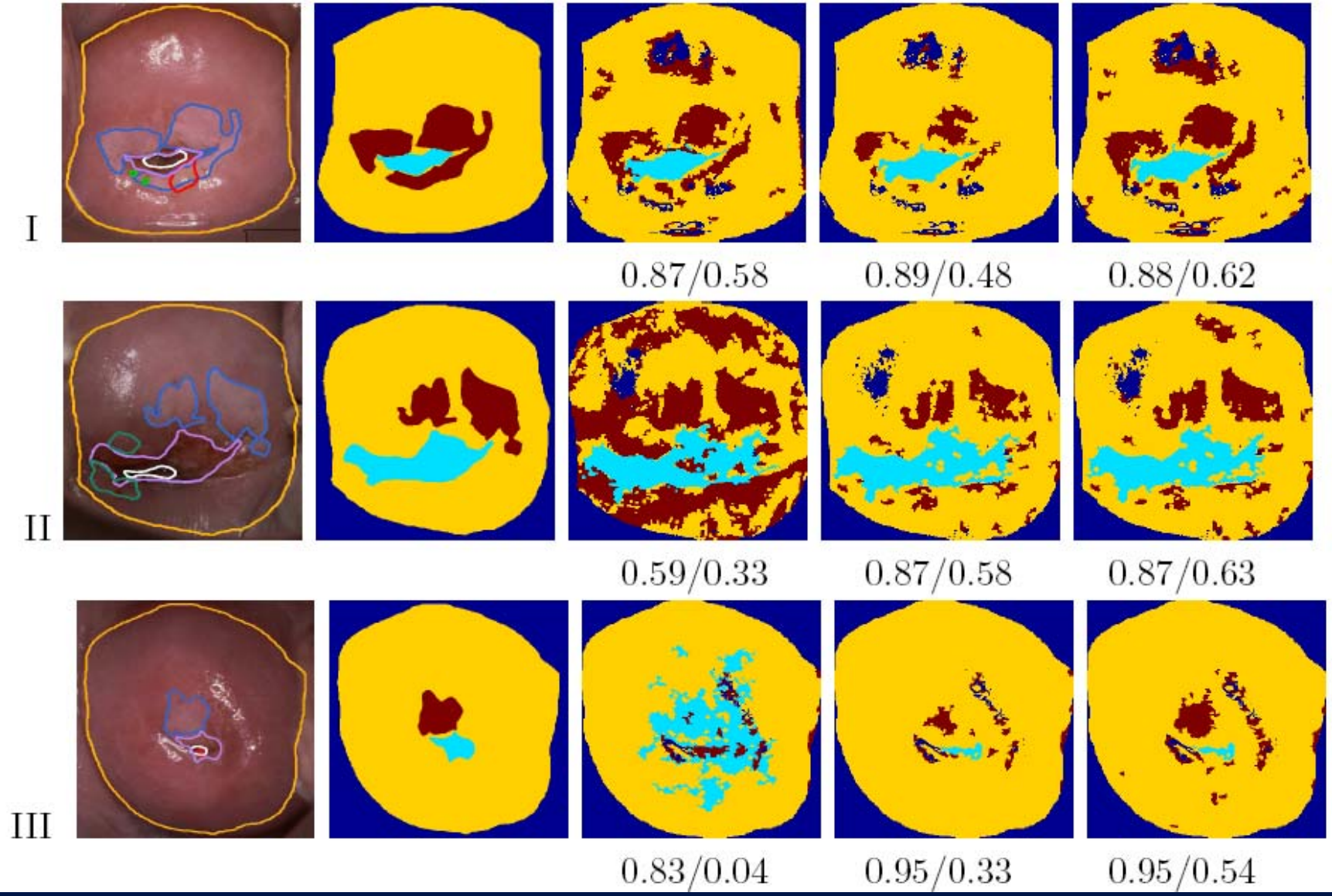


Automated Segmentation Before correction



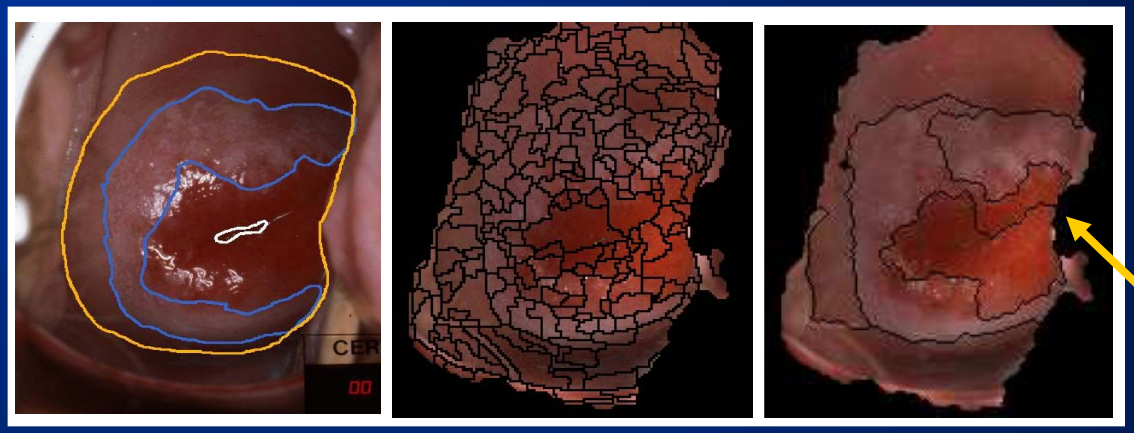
Automated Segmentation After correction

Tissue Segmentation



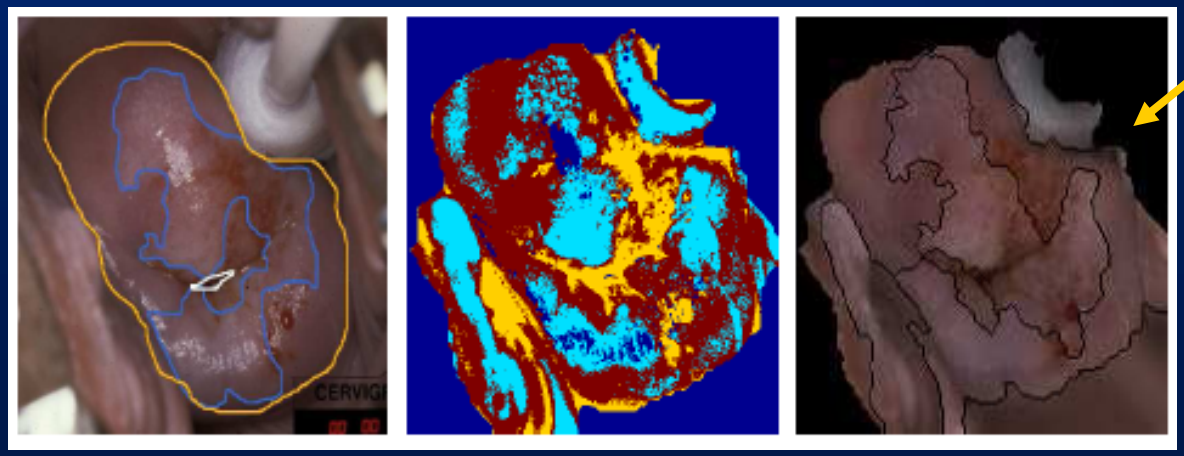
Segmentation of Non-Convex Regions within Uterine Cervix Images

[S. Gordon and H. Greenspan, *ISBI*, 2007]



Superpixels

Superpixel Segmentation



Pixel Segmentation

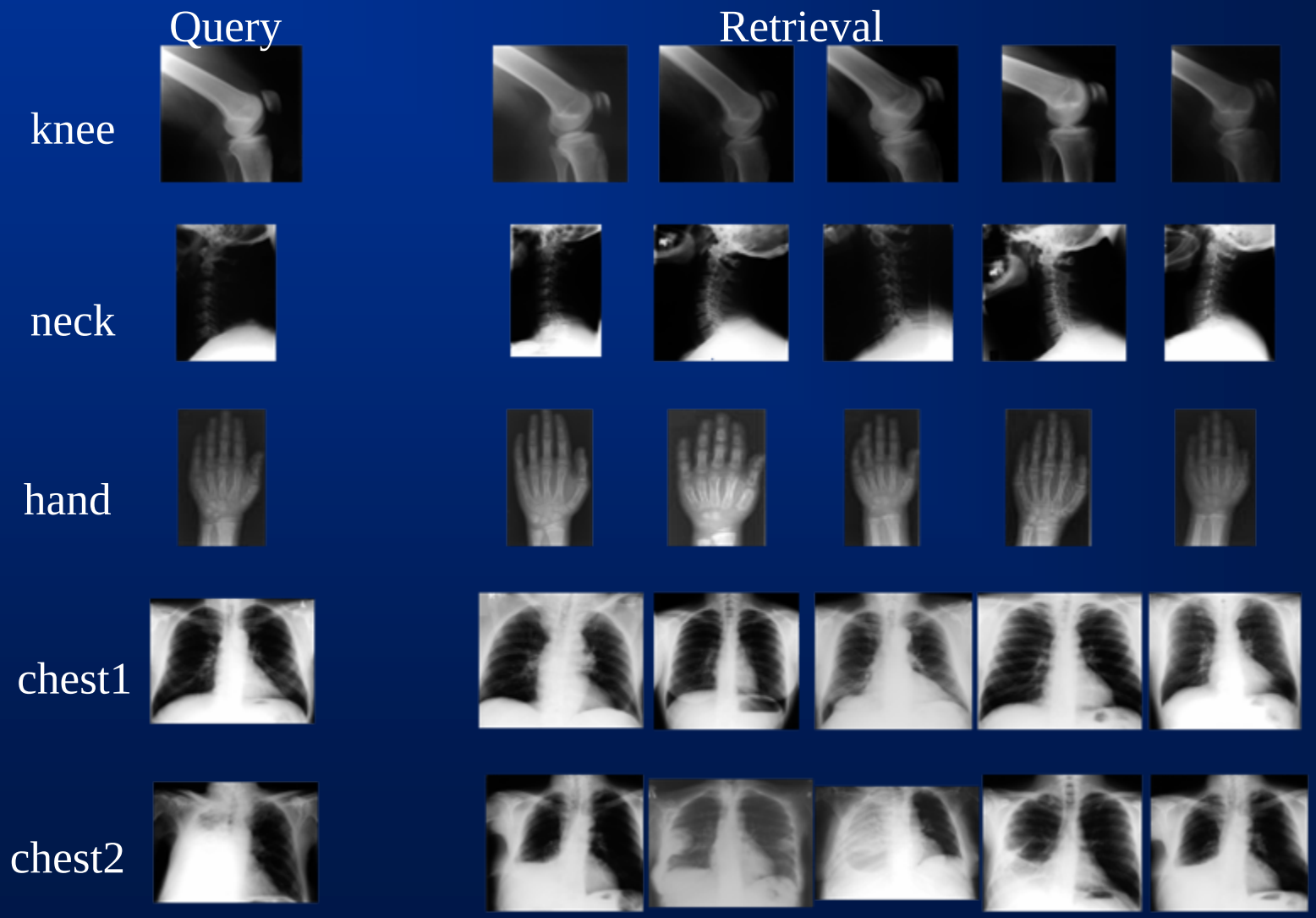
Some GAPS in Medical CBIR
When IMAGES are part of the CONTENT

From the Task to the Reality:

AUTOMATIC LANDMARK EXTRACTION,
SEGMENTATION & QUANTIFICATION
ARE DIFFICULT TASKS

Image 2 Image Matching

From the IRMA project, Aachen University Hospital (T. Deserno)
Radiograph archive – 1500 images, 17 classes



H. Greenspan and A. Pinhas. *IEEE Trans. on Information Technology in BioMedicine*, 2007.

Some GAPS in Medical CBIR
When IMAGES are part of the CONTENT

- Retrieving based on Image Landmarks
  From the Task to the Reality - An example

- Image 2 Image Retrieval
  What is a good image representation space?
  [Pixels, Histograms, GMMs]
  How do we compare between images?

- ROI based Retrieval

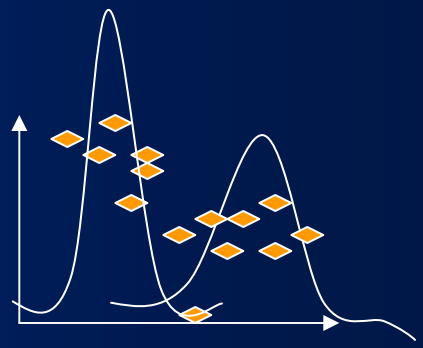
Image modeling using a Gaussian Mixture Model (GMM)

Pixels → Feature vectors → Regions

[I, texture, x, y]

$$f(X \mid \theta) = \sum_{j=1}^{k} a_j \frac{1}{\sqrt{(2\pi)^d \left|\Sigma_j\right|}} \exp\left\{-\frac{1}{2}(X-\mu_j)^T \Sigma_j^{-1} (X-\mu_j)\right\}$$

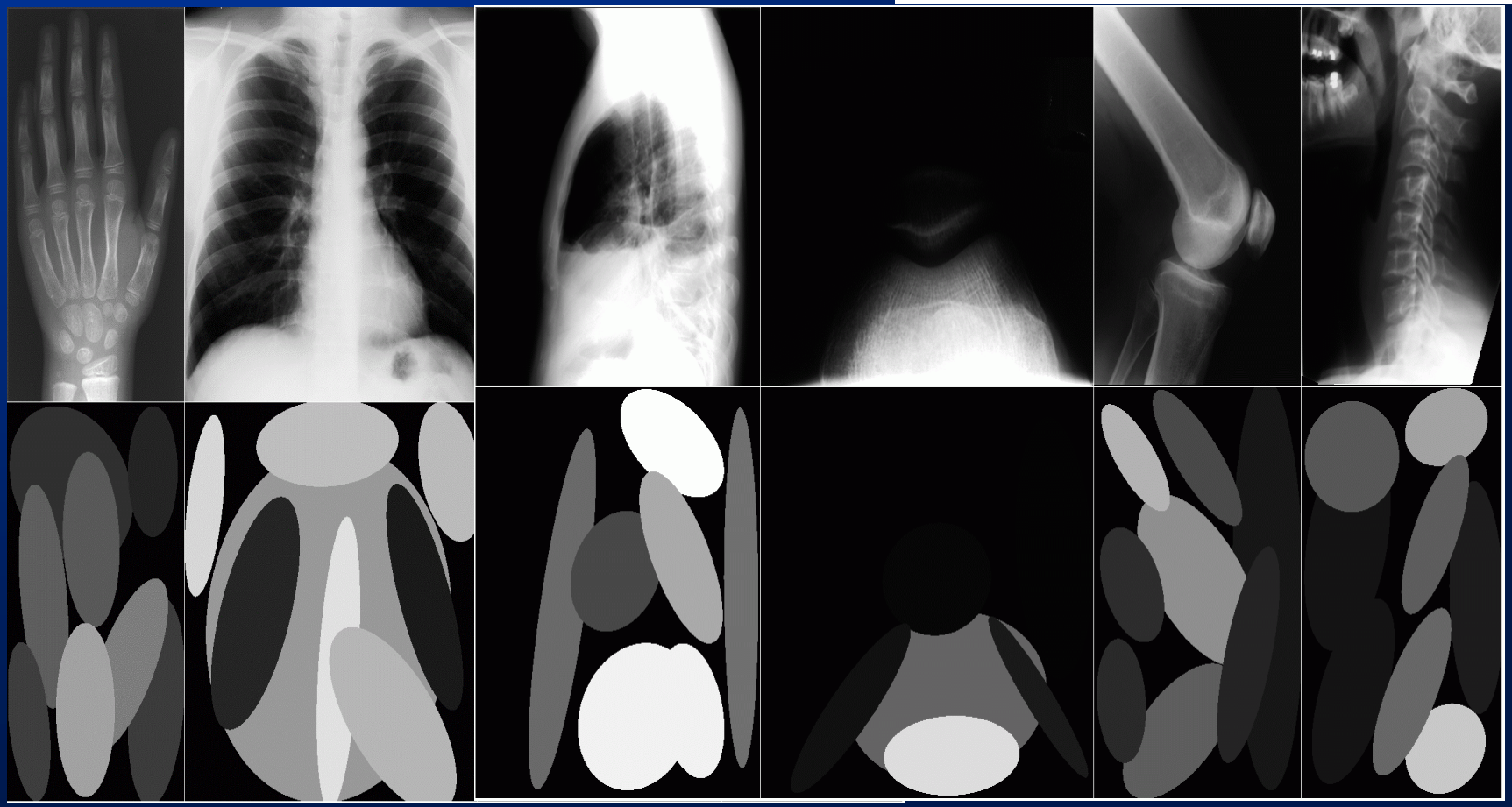
Parameter set: $\theta = \left\{a_j, \mu_j, \Sigma_j\right\}_{j=1}^{k}$



- Feature vectors are grouped in *d*-dimensional space – Unsupervised Clustering
- The image is modeled as a Gaussian mixture distribution (GMM)
- The Expectation-Maximization (EM) algorithm is used to determine the maximum likelihood parameters of the GMM

Image modeling via GMMs

Blobs in 4D space:
Intensity,Spatial(x,y),Texture



hand | chest | chest side view | patella | knee side view | neck side view

Levels of granularity in the representation

coarse ⟷ fine

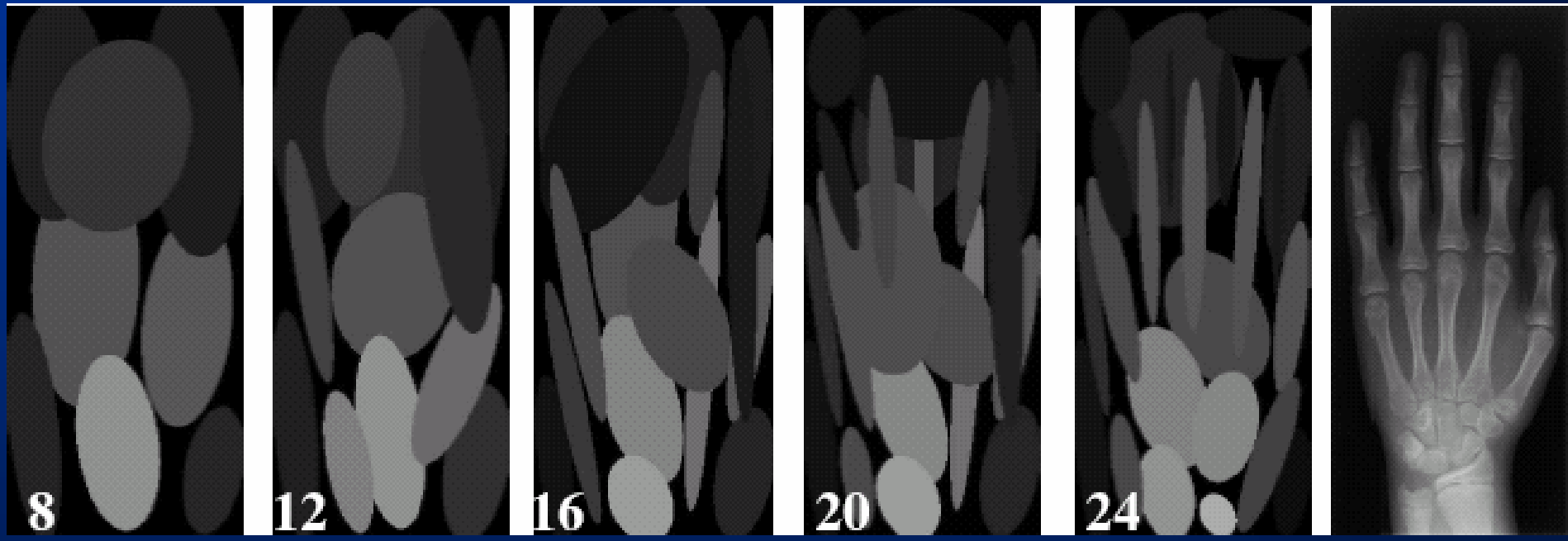


Image matching ⟷ Image segmentation

The KL measure for matching

Matching via
Kullback-Leibler
(KL) distance

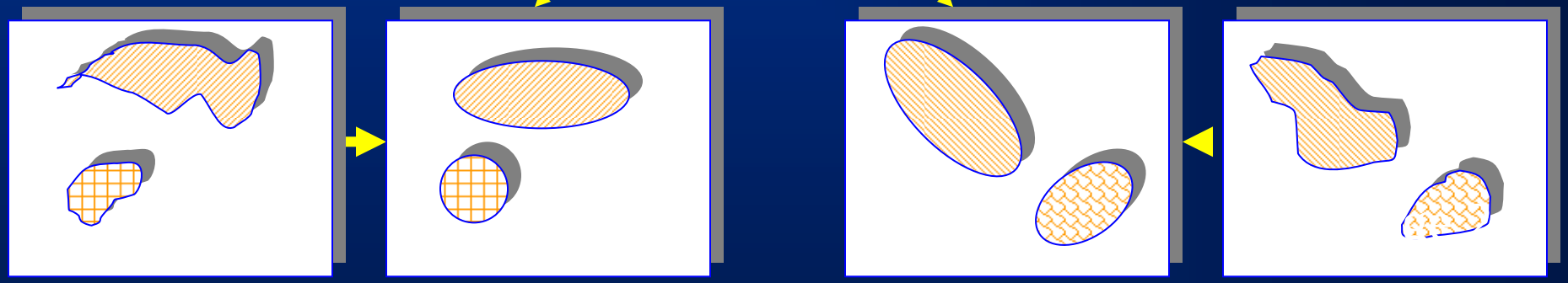


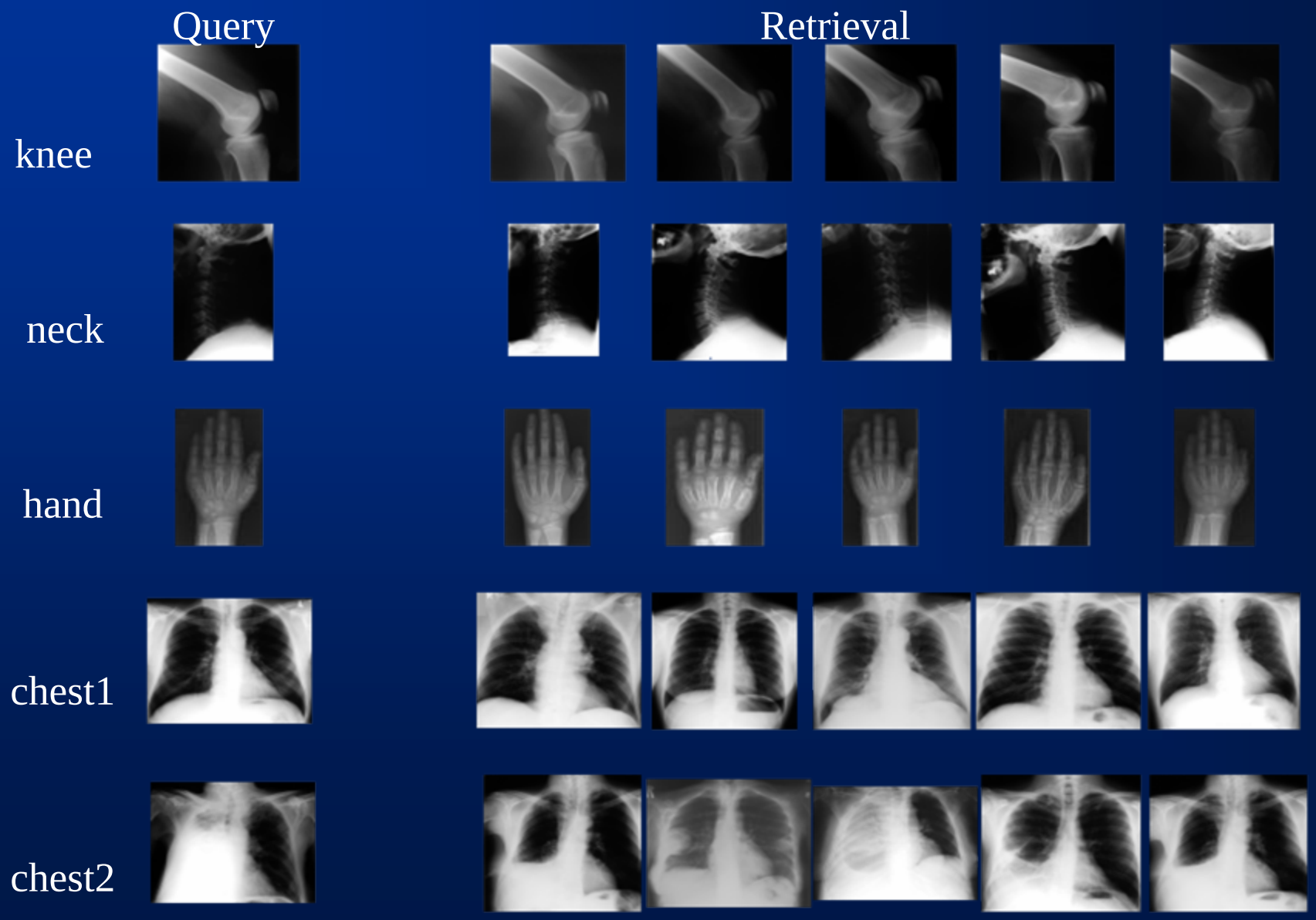
Image 1

Gaussian Mixture Representation

Gaussian Mixture Representation

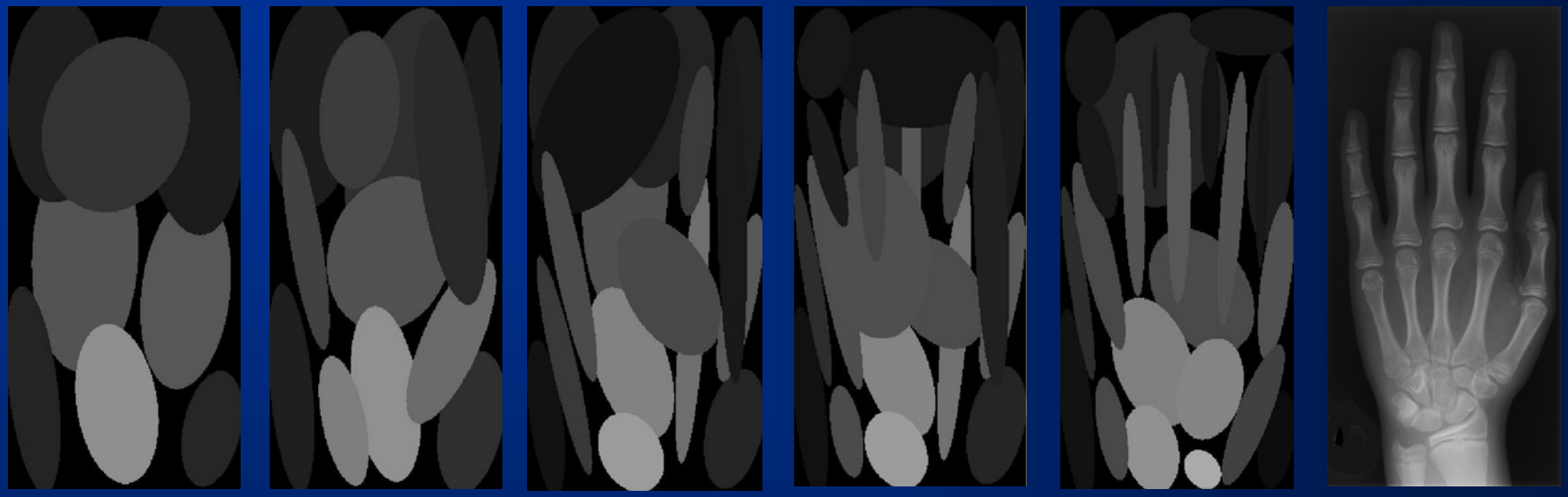
Image 2

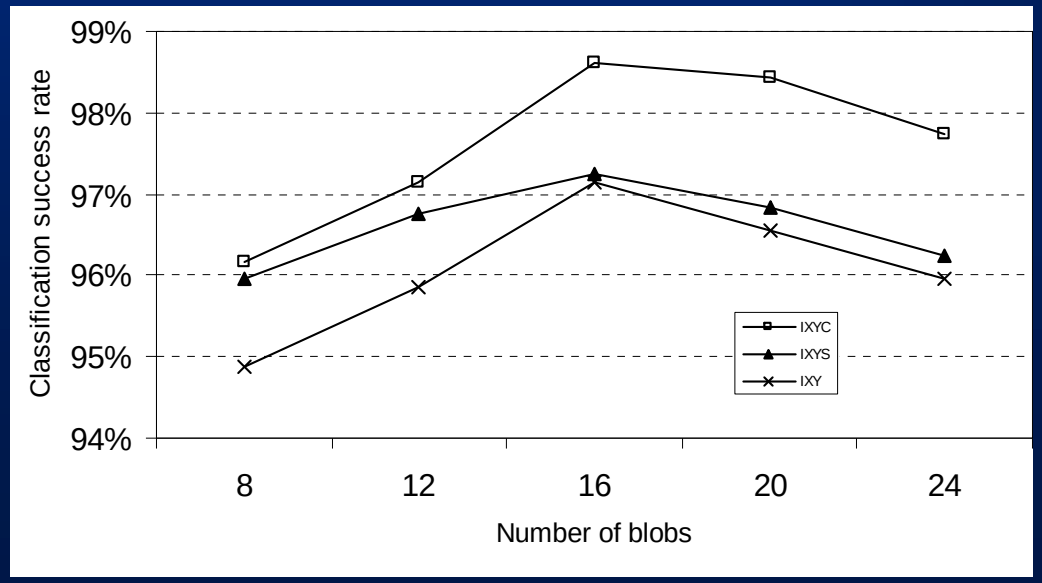
GMM-KL for Medical Image Retrieval
Radiograph archive – 1500 images, 17 classes



H. Greenspan and A. Pinhas. *IEEE Trans. on Information Technology in BioMedicine*, 2007.

What is K?

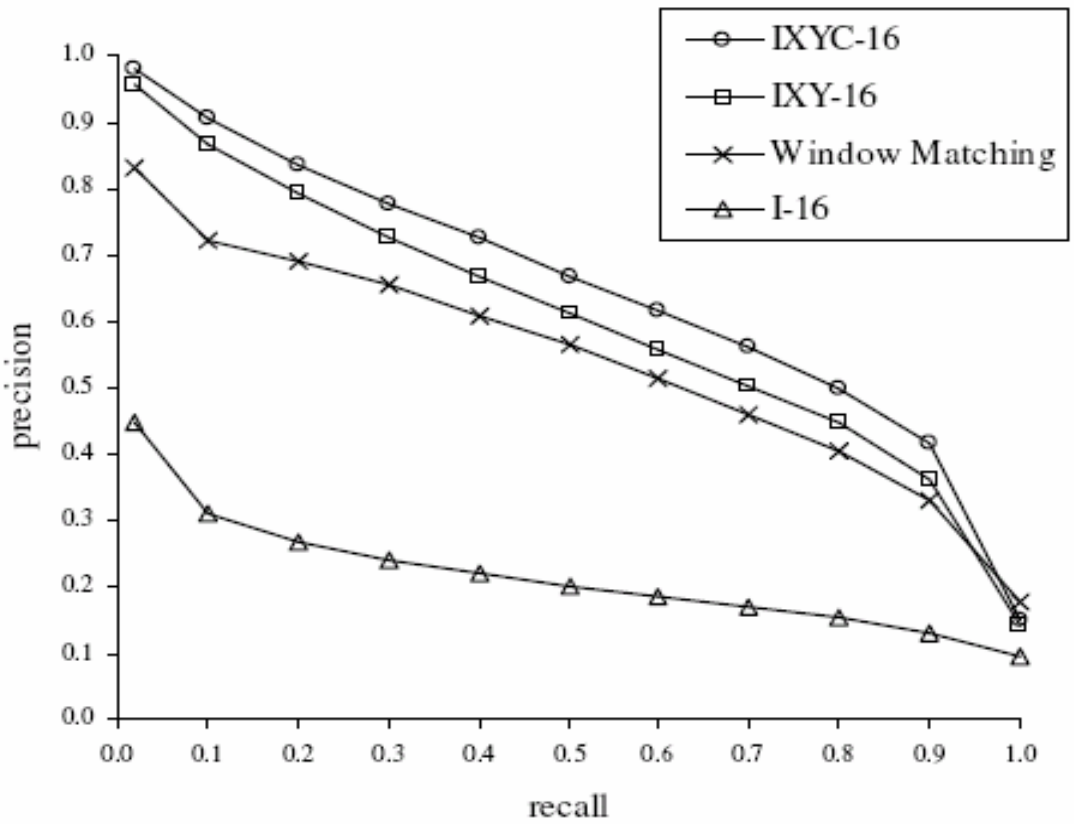




Feature space?
[I], [I,x,y]
[I,x,y,C]

Performance evaluation

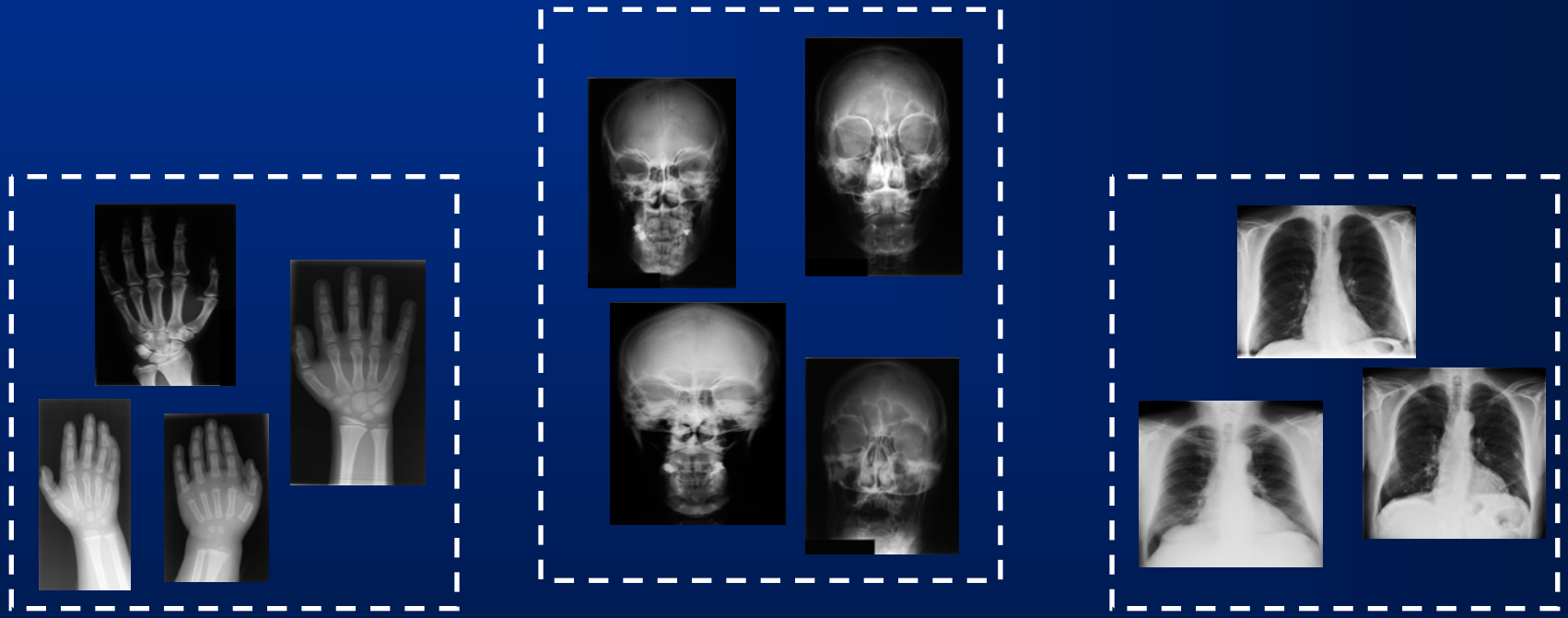
1501 images: 97.5% Classification



Precision: relevant items / items retrieved; Recall: relevant items / relevant in database

H. Greenspan and A. Pinhas. Medical image categorization and retrieval for PACS using the GMM-KL framework. IEEE Trans. on Information Technology in BioMedicine, 2007

GMM-KL for Image Archive Categorization

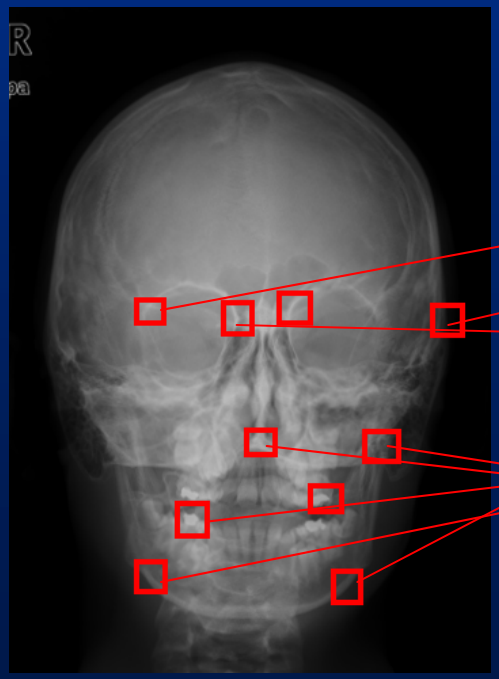


Mapping of images into groups of similar semantic content

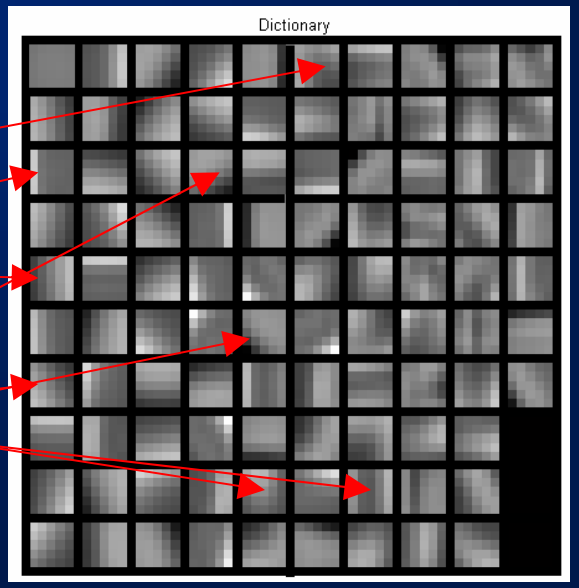
Image 2 Category Matching

Extending the Feature Space: From PIXEL-based to PATCH-based Representation

- Image is modeled as a collection of local patches.
- An image patch is represented by a single word from a Dictionary of words
- Dictionary is learned from entire dataset
- The entire image represented by a Bag of Words



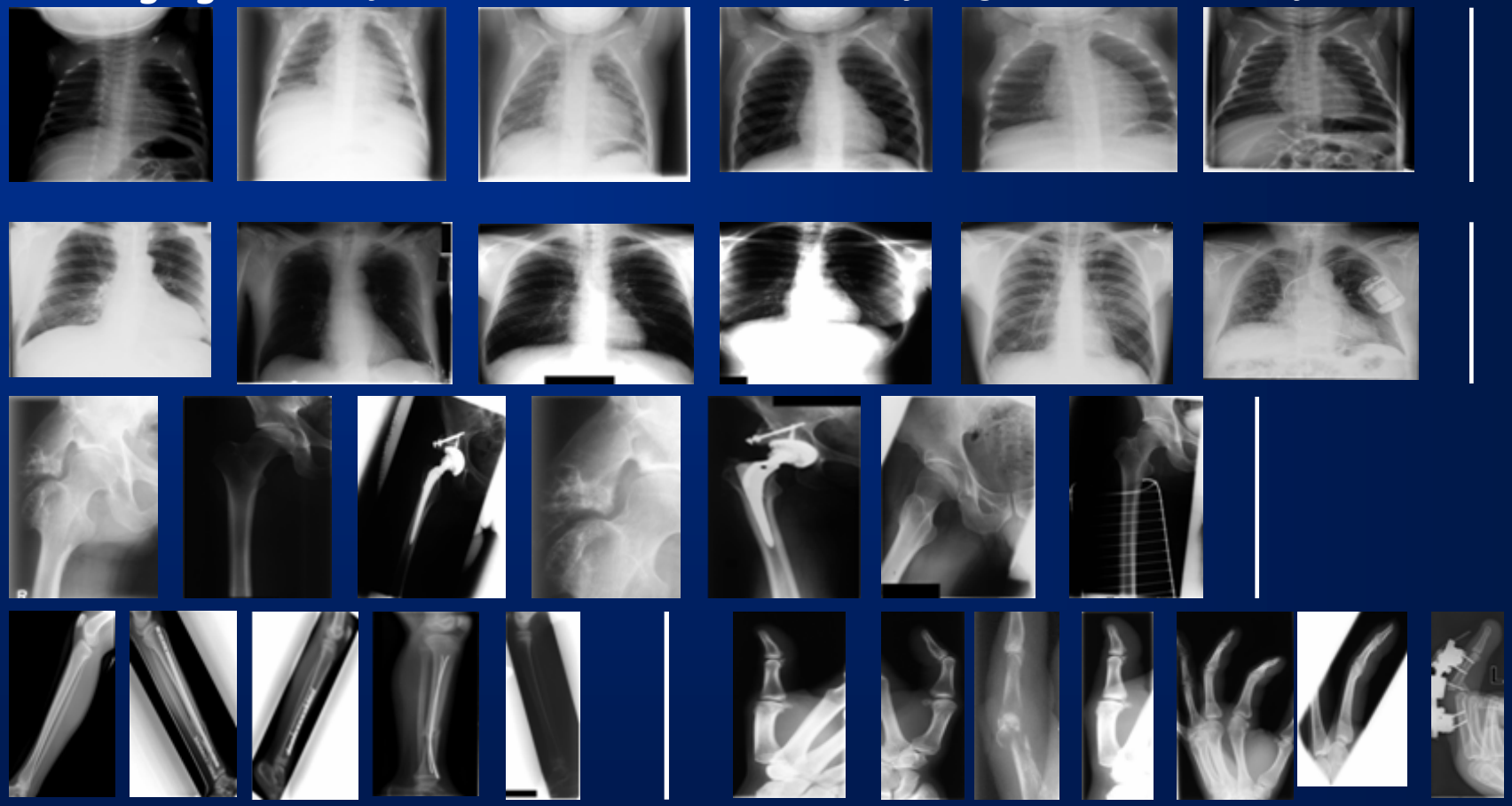
Image



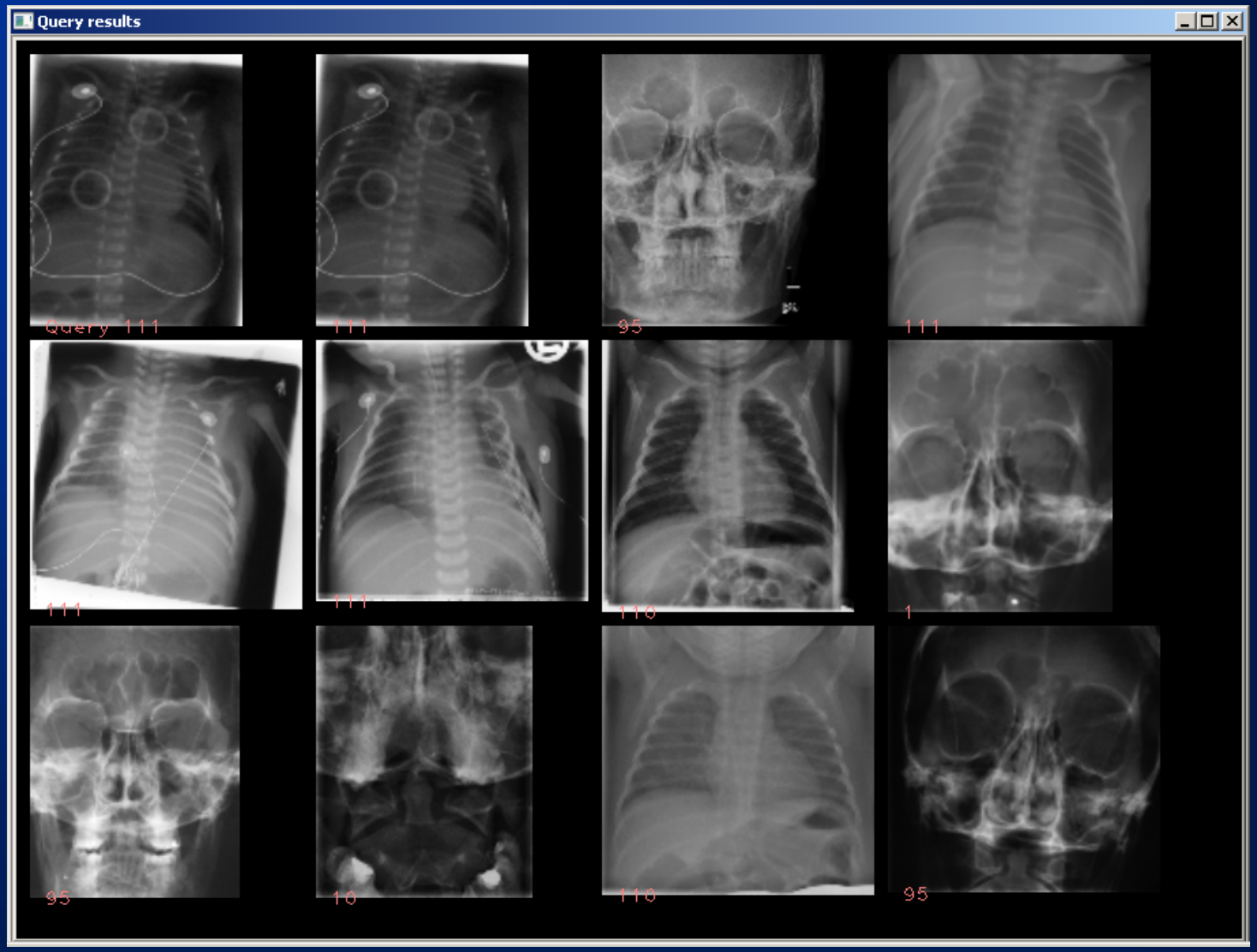
Dictionary

Some Images From CLEF2007 Database: 12000 images; 116 categories

Imaging modality; orientation; examined body region; functional system.

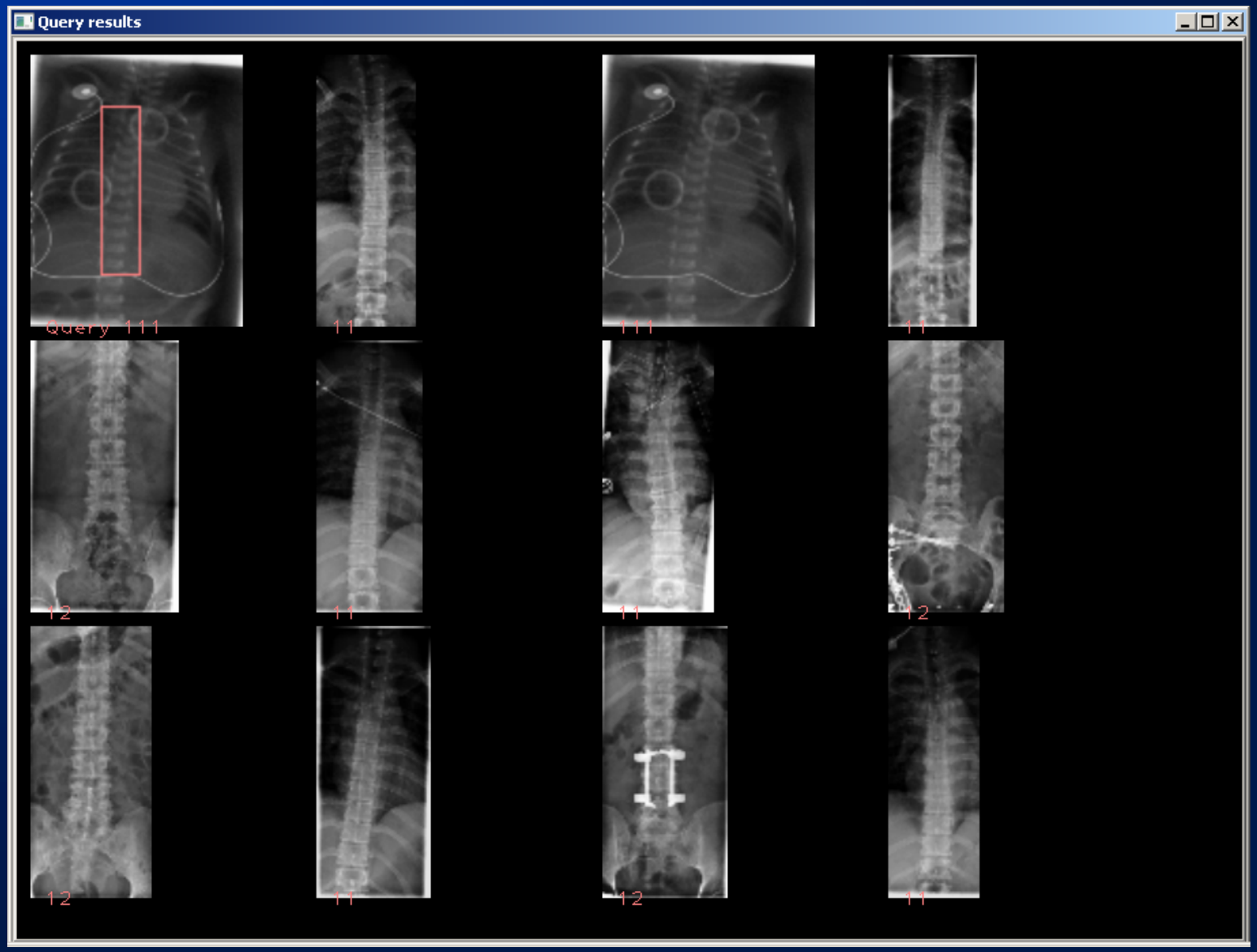


On 1000 test images – close to 90% correct classification



Clinical Applications ?

ROI based Retrieval



Selecting the spine as a ROI returns images with a central vertical spine

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