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# CSI 4107

## Image Information Retrieval

This slides are inspired by a tutorial on Medical Image Retrieval by Henning Müller and Thomas Deselaers, 2005-2006

# Outline

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- Introduction
- Content-based image retrieval
- Examples of systems
- Image processing
- Visual features
- Matching and classification of images
- Medical applications
- Other media / multimedia

# The need for content-based visual IR

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- Rising amount of visual data is produced digitally
  - Digital cameras at consumer prices
  - Publications on the Internet (Billions of images)
  - Journalists (Millions of images produced every day)
  - Trademarks (>100.000 visual marks in Switzerland alone)
  - Hospitals (Geneva radiology: >30,000 images per day)
- Only small part of the images is annotated
  - Annotation is expensive, subjective, task dependent
  - Not everything can be described by text

# Content-based image retrieval (CBIR)

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- The term “content” refers to colors, shapes, textures, or any other information that can be derived from the image itself.
- Without the ability to examine image content, searches must rely on **metadata** such as captions or keywords, which may be laborious or expensive to produce.

# Problems

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- How to formulate a query visually?
  - Sketch
    - Colored regions
  - Example image
    - But how to get a good example?
  - Regions in example images
    - Pre-segmented; marked with a pencil
- How to represent an image with “features”
  - Without knowing what someone is looking for
  - Features need to be extracted automatically

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# Examples of systems

# QIBC

## Query by image content

- IBM, commercial product, 1993
- Add-on for DB2
- Simple color, texture, layout features
- Very simple feedback

Usage: **I**: Get Info **C**: Color Histogram **L**: Layout **T**: Texture **S**: Special Hybrid Color

Keywords:

Previous Next

Query was:


Example: =u380337.jpg

Query Type: Color Layout

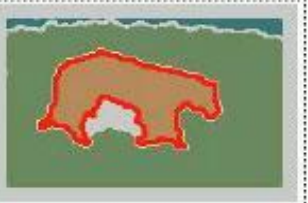
# Blobworld, 1997

Netscape: Blobworld Query Results: image #108019 (Prefiltered)

File Edit View Go Communicator Help




Query image: 108019



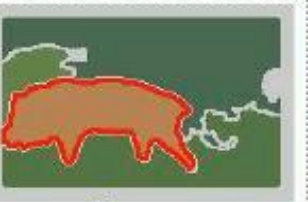
Query blobs

		feature importance:				
		overall	color	texture	location	shape
blob		very	very	somewhat	not	not
background		somewhat	very	not	not	not


Querying from 35000 images (2000 returned by the filter).




1: 108044 (score = 0.99)




[New query](#)




2: 108023 (score = 0.98)




[New query](#)




3: 108006 (score = 0.98)




[New query](#)




4: 108029 (score = 0.98)




[New query](#)




5: 108051 (score = 0.98)




[New query](#)




6: 108084 (score = 0.97)




[New query](#)




7: 108037 (score = 0.97)



[New query](#)



8: 108004 (score = 0.97)



[New query](#)



[www.airliners.com](http://www.airliners.com)

Nearly 1,000,000 aviation images online. Can be searched by similarity using SIMPLicity from Penn. State Univ.

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The screenshot shows a web browser window with the URL [http://www.airliners.net/search/similarity\\_search.php?photo\\_id=41](http://www.airliners.net/search/similarity_search.php?photo_id=41). The browser's address bar includes navigation buttons and a search engine icon. Below the address bar is a navigation menu with links for HOME, PHOTOS, SEARCH, NEWS, ARTICLES, A/C DATA, FORUM, PLANE FUN, STORE, and ABOUT. The main content area features a large image of a Boeing 747 aircraft in flight, with the text "THE WINGS OF THE WEB" and "AIRLINERS.NET" overlaid. Below the aircraft image, it says "262 users checked-in. You are not checked-in. No username? Join us!". A text box explains the similarity search feature, stating it compares colors, contrast, and shapes in images. It mentions that this is cutting-edge science and work in progress, and that Airliners.net is in cooperation with Profs. James Z. Wang and Jia Li at PSU. A link is provided to read more about the feature and post comments.

HOME PHOTOS SEARCH NEWS ARTICLES A/C DATA FORUM PLANE FUN STORE ABOUT

# THE WINGS OF THE WEB

## AIRLINERS.NET

262 users checked-in. You are not checked-in. No username? [Join us!](#)

This section displays photos similar to your query image. It does not show photos of a particular airline or aircraft (use our normal keyword based search engine for that) but instead compares colors, contrast and shapes in the images themselves. This is cutting edge science and work in progress. Getting a computer to perceive similarity between images the same way as you and I is extremely difficult and the base of much scientific research. Airliners.net in cooperation with Profs. James Z. Wang and Jia Li at PSU bring you one of the best similarity search engines in the world applied to the Airliners.net photo database. Enjoy!

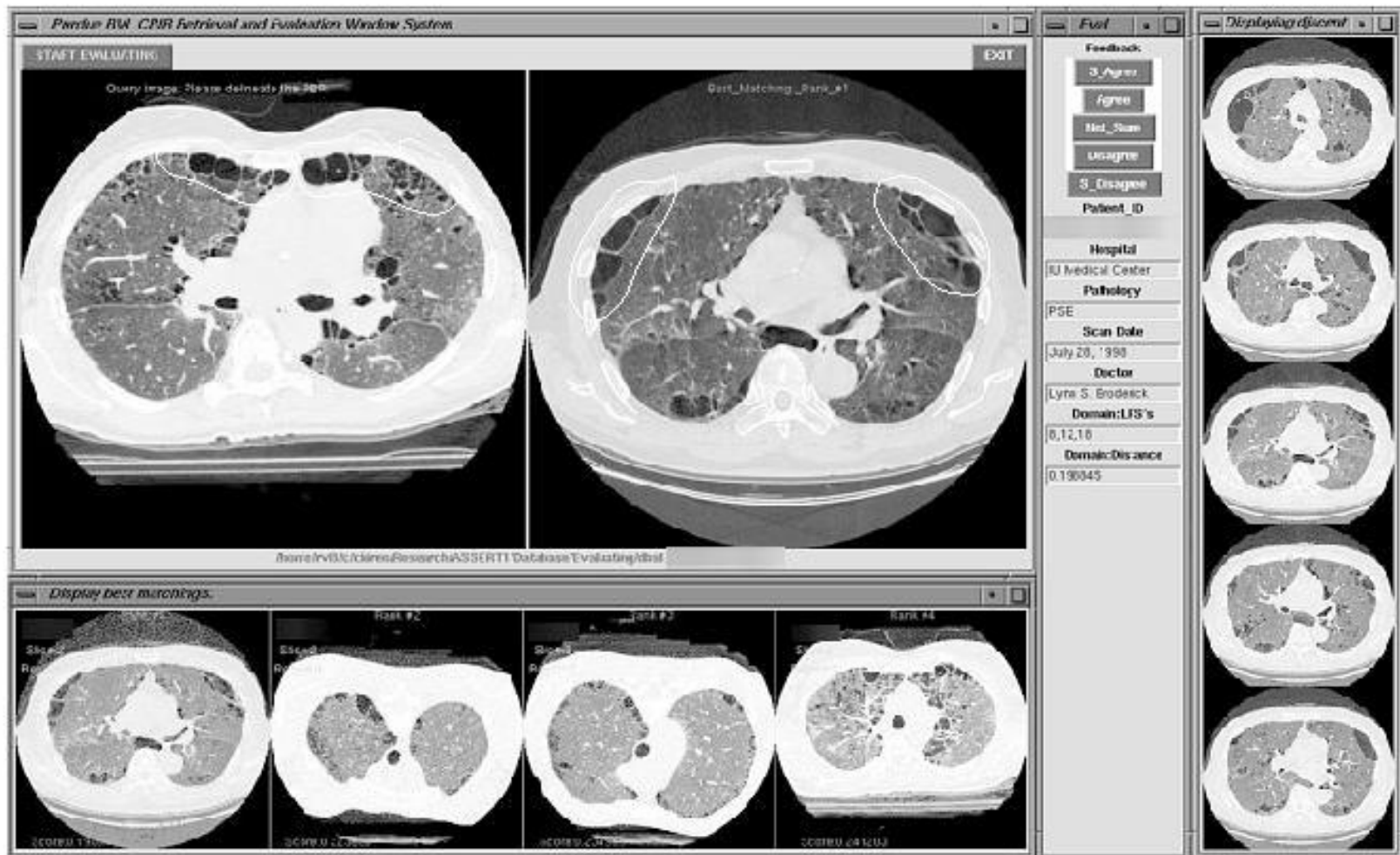
Read more about this feature (including how to use your own photos as query images!) and post your comments [here](#)



Three small images showing different views of an airplane cockpit, likely related to the search results or the feature being described.

# ASSERT

## Medical Image Retrieval, 2006



# Google Image Search

- Purely based on text
- Searching for ambiguous words may lead to confusion

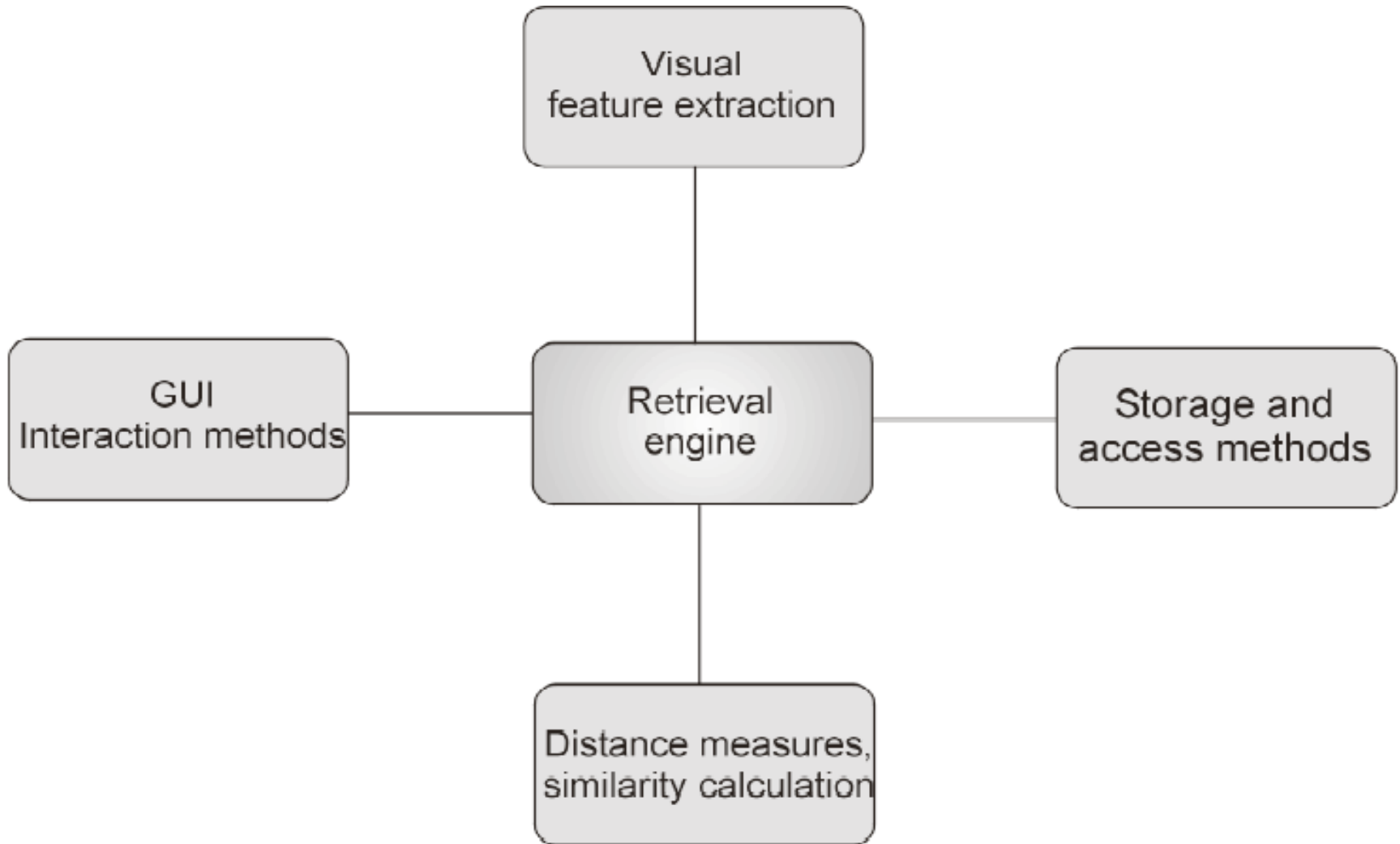
The screenshot shows a web browser window with the Google Images search interface. The search query is 'radiograph'. The results page displays a grid of image thumbnails with their respective file names, dimensions, sizes, and source URLs. The results include:

- Radiograph.jpg**: 593 x 833 pixels - 362k, from [www.matsci.ucdavis.edu/.../images/Radiograph.jpg](http://www.matsci.ucdavis.edu/.../images/Radiograph.jpg)
- radiograph.jpg**: 175 x 226 pixels - 3k, from [vmthpub.vetmed.wisc.edu/.../fractures.htm](http://vmthpub.vetmed.wisc.edu/.../fractures.htm)
- morph3.jpg**: 380 x 520 pixels - 42k, from [www.dartmouth.edu/.../morph/morph3.html](http://www.dartmouth.edu/.../morph/morph3.html)
- radiograph lateral c spin...**: 1499 x 1243 pixels - 124k, from [www.acvr.ucdavis.edu/activities/meetings/mont...](http://www.acvr.ucdavis.edu/activities/meetings/mont...)
- xray\_bird.jpg**: 228 x 218 pixels - 10k, from [americanhistory.si.edu/anatomy/preservation/n...](http://americanhistory.si.edu/anatomy/preservation/n...)
- plainImage.jpg**: 760 x 400 pixels - 53k, from [info.med.yale.edu/.../specimen\\_w\\_radiograph](http://info.med.yale.edu/.../specimen_w_radiograph)
- Xray.gif**: 216 x 300 pixels - 47k, from [www.med.harvard.edu/JPNM/TF99\\_00/Sept21/Xray.gif](http://www.med.harvard.edu/JPNM/TF99_00/Sept21/Xray.gif)
- 180px-Roentgen-x-ray-von-...**: 180 x 270 pixels - 19k, from [en.wikipedia.org/wiki/X-ray](http://en.wikipedia.org/wiki/X-ray)

The browser's address bar shows the URL: <http://images.google.com/images?q=radiograph&hl=en&btnG=Se>. The search bar contains the text 'radiograph'. The page title is 'Images' and the search results are 'Results 1 - 20 of about 8,600 for radiograph. (0.31 seconds)'. The search bar also includes a 'Search' button and links for 'Advanced Image Search' and 'Preferences'. The browser's status bar at the bottom shows 'Done' and 'Adblock'.

# Content-based Image Retrieval: System architecture

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# Image processing

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- Image capture and discretization (when the collection is built), color spaces, file types, etc.
- Pre-processing: normalization of brightness, filters, contrast, etc.
- Extraction of visual features
- Image comparison

# Image segmentation

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- It is at the threshold between image processing and image analysis.
- Different approaches:
  - pixel-based
  - region-based
  - edge-based
  - model-based
- Requires high-level knowledge of the image content (content understanding, e.g., face recognition systems).

# Image processing for CBIR

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- Two important questions for content-based image retrieval:
  - how are images represented => features
  - how are image representations compared => distance/similarity measures
- Two views on the concept of ‘feature’:
  - features are numerical values computed from each image view connected to image classification  
learn from **classification and machine learning**
  - features are image properties that are present or absent view connected to text retrieval  
learn from text retrieval

# Features

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- **Visual features**
  - color, texture, shape, ...
- **Statistical features**
  - histograms, invariant features, ...
- **Model-based approaches**
  - image comparison, holistic, active shapes, active contours



# Visual Features

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- **Color:**
  - very good feature for general images
  - different color spaces can be used: RGB, HSV/HSI, ...
  - colors are values at pixel level; need to combine colors into a feature vector, for most distance measures
  - color histograms
- **Texture:**
  - different representations possible
  - global / local texture descriptors
- **Shape:**
  - very difficult to determine for general images
  - alternative: local shape parts

# Example: Tamura Texture Feature (proposed by Tamura et al. 1978)

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- features corresponding to human perception
- examined 6 different features, three correspond strongly to human perception
  - **coarseness** – coarse vs. fine
  - **contrast** – high vs. low
  - **directionality** – directional vs. non-directional
  - line-likeness – line-like vs. blob-like
  - regularity – regular vs. irregular
  - roughness – rough vs. smooth
- calculate the first three features pixel-wise
- create a 3d histogram of these features



# Matching: Distance Measures

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## **Image comparison measures**

- Euclidean distance
- Tangent distance
- Image distortion model

## **Local feature comparison measures**

- Direct transfer
- Image based

## **Region comparison measures**

- Integrated region matching
- Quantized matching

## **Histogram comparison measures**

- Minkowski: Euclidean, L1
- Histogram intersection
- Relative deviation
- CHI<sup>2</sup> distance
- Kullback-Leibler divergence, Jensen-Shannon divergence
- Quadratic forms
- Earth movers distance
- Time warp distance

# Medical domain

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- Differences:
  - Currently images are almost always accessed by patient ID, only
  - Problems to use images for other tasks than directly for healing a single patient (laws)
- Images are mainly in gray levels
  - Saliency models might not work
  - Color invariance models do not work
  - BUT: images often taken under standardized conditions
- Imaging modalities change and can produce very different images
  - Advances in modalities can be quick

# Other multimedia data for retrieval

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- Text (web pages mixed with other media)
- Images, graphics, ...
- Signals (ECG, EEG)
- Sound
  - Music retrieval
- Video
  - Mix of media sound and temporal series of images
- 3D data
  - Tomographic images
  - Constructions