

- Introduction to image databases**
- 6.1 – Generalities
 - 6.2 – Retrieval based on key-words
 - 6.3 – Retrieval based on content
 - 6.4 – Physical structuring of image databases
 - 6.5 – Example: Image Rover
 - 6.6 – Conclusions

6.1 – Generalities

- Several types
 - Collections of fixed images
 - Very big rasters
 - Raster maps
 - Aerial photos
 - Satellite images
 - Video Sequences, films

Retrieval

- Based on key-words (typically a user gives a list of key-words)
- Based on content (user gives an image-example (query by example))
 - colors
 - shapes
 - textures
 - spatial relations

High and low level characteristics

- High Level Characteristics
 - nature and semantics of objects present on image, and their relations
 - example : a boat on the sea at sunset
- Low Level Characteristics
 - pixels, colors, textures, etc.
 - example : images with 40 % of light blue.

Interrogation of image bases

- Retrieval based on key-words
- Retrieval based on content
- Retrieval based on colors
- Retrieval based on shapes

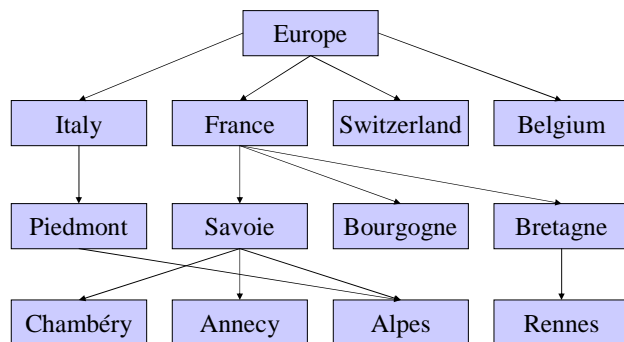
6.2 – Retrieval based on key-words

- Each image is described by a list of key-words (operation named indexing)
- Generally from 3 to 10 key-words given by the author or by an expert
- Those key-words are regrouped in a thesaurus with 3 relations
 - synonymy
 - genericity / specificity

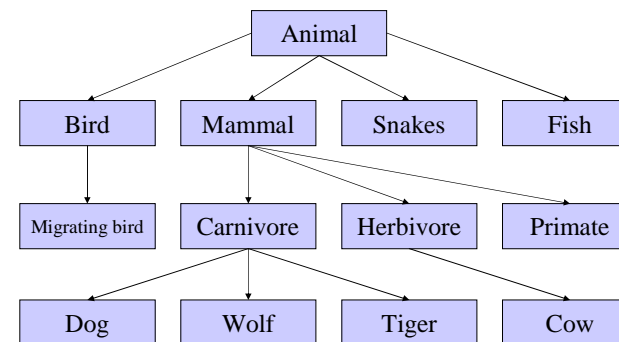
Annotations

- Additional Information
- Retrieval of key-words characterizing MM documents
- Lists of objects, persons, etc.
- Origin of the document (author, device, date, etc.)
- Generally made visually
- Seldom named “manual indexing”

Example of a geographic thesaurus



Other example of thesaurus

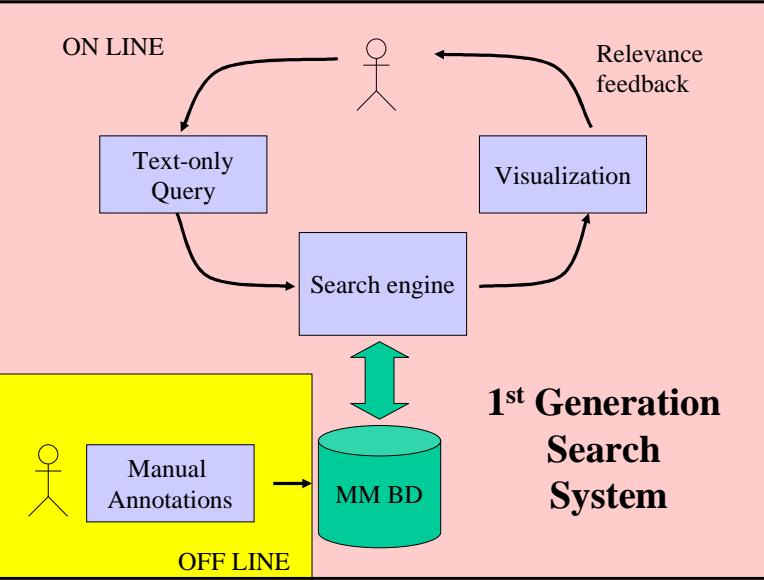


Queries

- Boolean list of key-words (AND, OR, EXCEPT)
- Noise = too much non relevant documents
- Silence = too less or absence results
- Example : *“I looking for photos dealing with the culture of cauliflowers in Australia”*

Reformulation

- R: culture and cauliflower and Australia
- Transformation of the query based on thesaurus
- R': (culture except civilization)and cauliflower or vegetable)and(Australia or Oceania)



Keyword: Beach

Corel Stock Photos http://elib.cs.berkeley.edu/cgi/img_corel_query

Note: Corel images are for viewing only and may not be downloaded or saved.

Number of matches: 600


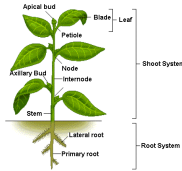
Search for: keywords like "beach"

 ID: 24400 Diskname: Beach Caption: Puerto Morelos, Yucatan, Mexico	 ID: 24401 Diskname: Beach Caption: Walks Beach, Hawaii	 ID: 24402 Diskname: Beach Caption: Beach At Alameda, Portugal	 ID: 24403 Diskname: Beach Caption: Beach At Alameda, Portugal
 ID: 24404 Diskname: Beach Caption: Unfinished Island Beach, Bermuda	 ID: 24405 Diskname: Beach Caption: Costa Blanca, Spain	 ID: 24406 Diskname: Beach Caption: Shores, Portugal	 ID: 24407 Diskname: Beach Caption: Cliff, Val Des Lacs, Portugal
 ID: 24408 Diskname: Beach Caption: A SeaKobe Explorer The South Of Boston, Atlantic Ocean	 ID: 24409 Diskname: Beach Caption: Devonian Beach, Bermuda	 ID: 24410 Diskname: Beach Caption: Fort Hood Beach And Park, Cape Breton, Nova Scotia	 ID: 24411 Diskname: Beach Caption: Annapolis And Virginia Of All Beaches Harbor

Plant database

Linnaean Taxonomic Hierarchy

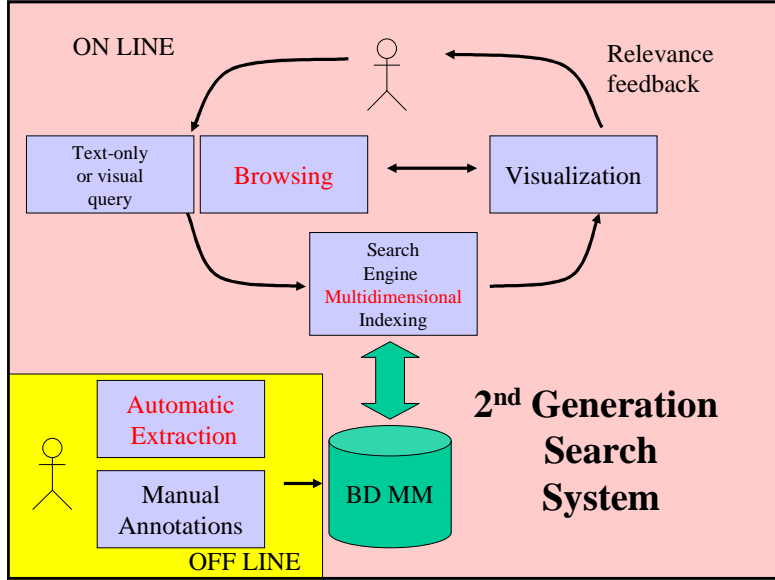
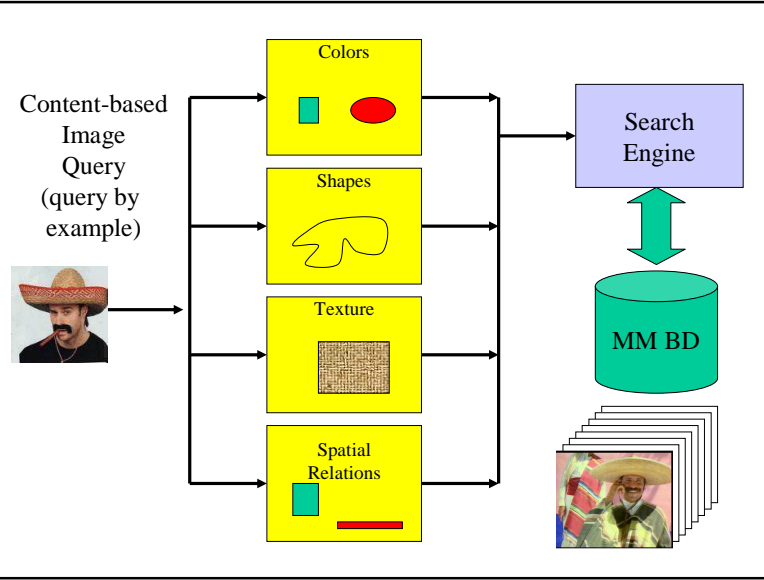
CATEGORY	
1. Kingdom	Plantae
2. Division	Angiosperms
3. Class	Dicotyledons
4. Order	Asterales
5. Family	Asteraceae
6. Genus	Helianthus
7. Species	Helianthus annuus

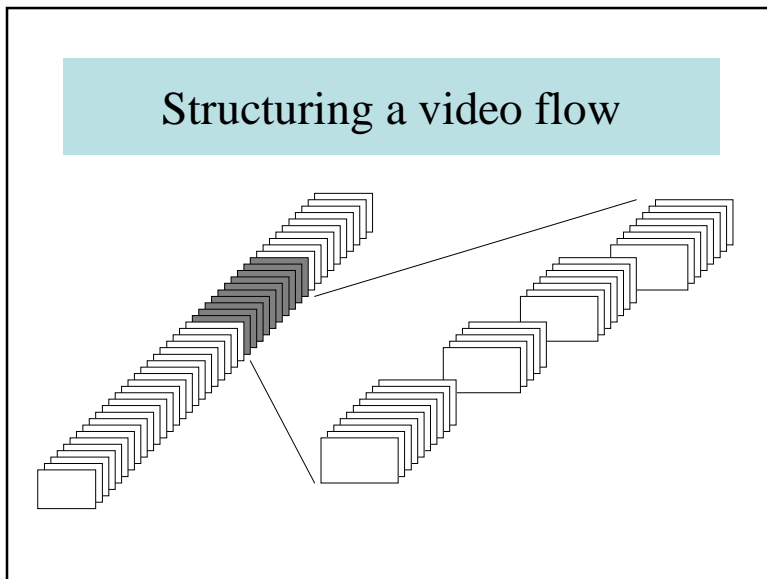



<http://www.ualr.edu/~botany/images.html>

6.3 – Retrieval based on content

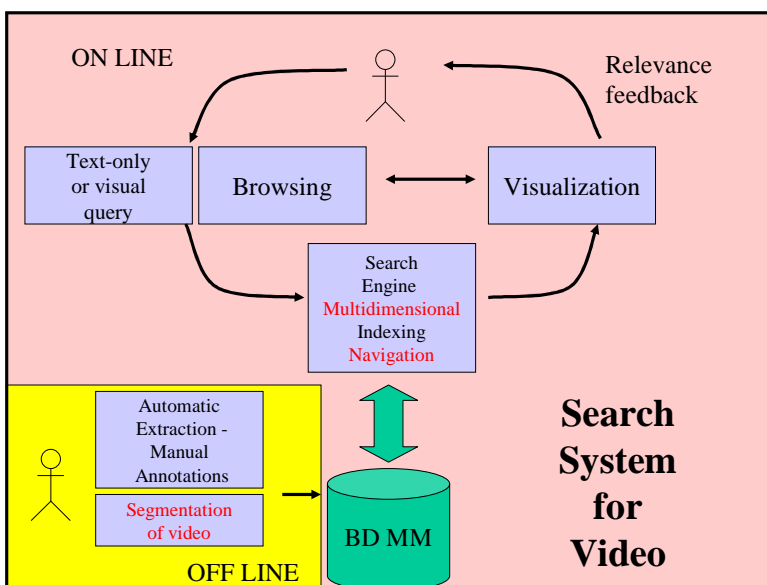
- Generally based on an example “*Query-by-example*”





Segmentation

- Manual vs. automatic Segmentation
- Splitting in
 - episodes
 - scenes
 - shots
- Semantics (same actor, same place, etc.)



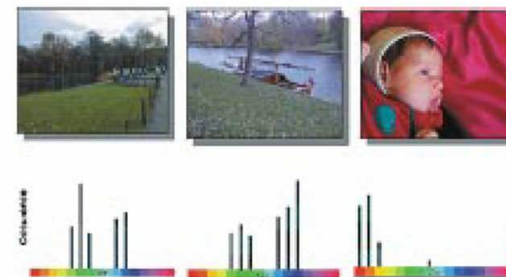
Content-based Retrieval

- 6.3.1 – Retrieval based on colors
- 6.3.2 – Retrieval based on shape
- 6.3.3 – Retrieval based on parameters
- 6.3.4 – Retrieval based on spatial relations

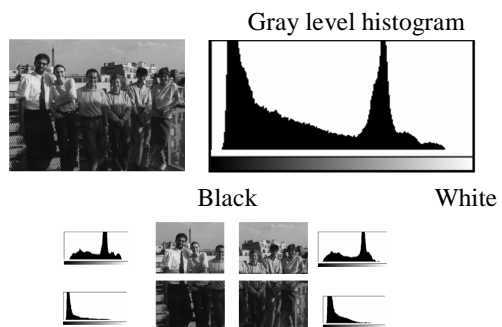
6.3.1 – Retrieval based on colors

- Containing a color in a certain proportion
- Similarity of colors in the whole image
- Similarity of only a part
- Based on an object having some particular color
- etc.

Example of histograms



Histograms of regions



Solution

- Histogram of colors for the image-query $H(I_Q)$ and for other images $H(I_D)$
- Attention: same resolution, same color-encoding system

Comparison of histograms

$$D_H(I_Q, I_D) = \sum_{j=1}^n |H(I_Q, j) - H(I_D, j)|$$

$$D_H(I_Q, I_D) = \sqrt{\sum_{j=1}^n (H(I_Q, j) - H(I_D, j))^2}$$

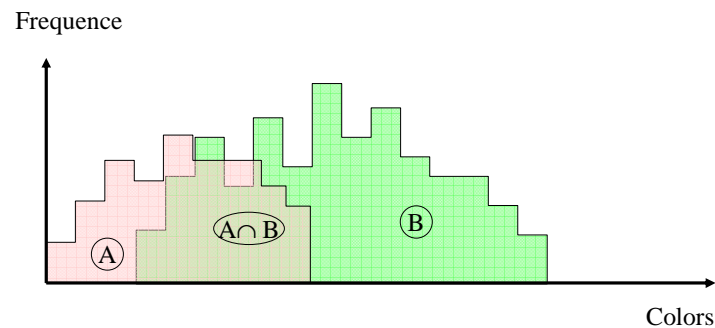
- Comparison by test (χ^2 type)
- But weak performances

Method of Swain and Ballard

- Intersection of histograms

$$D_H(I_Q, I_D) = \frac{\sum_{j=1}^n \min(H(I_Q, j), H(I_D, j))}{\sum_{j=1}^n H(I_Q, j)}$$

Intersection of histograms



Blobworld

<http://elib.cs.berkeley.edu/photos/blobworld/>

- University of California, Berkeley
- 35 000 images

Step 1:

To begin a query, select a blob by clicking in the Blobworld image above.

You can also type in one or more keywords. We'll search the Corel keywords, caption, and CD title, and only do the Blobworld search among images that match all of your keywords. (But read this [warning](#) about the inaccuracy of keywords.)

Or search based on keywords alone. -- just type the keywords and click "Submit."

Step 2:

Adjust the weights below if you'd like, then click "Submit."

	Not Somewhat Very			Not Somewhat Very		
How important is the selected region?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	How important is the background (everything outside the region)?	<input type="radio"/>	<input type="radio"/>
How important are the features of this region?						
Color	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>			
Texture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>			
Location	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>			
Shape/Size	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>			

		Feature importance:			
	overall	color	texture	location	shape
blb	very	very	somewhat	not	not
background	somewhat	very	not	not	not

Query image: 108019 Query mask

Querying from 33000 images (200 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. 108024 (score = 0.97) New query

7. 108037 (score = 0.97) New query

8. 108004 (score = 0.97) New query

MARS <http://www-db.ics.uci.edu/pages/research/mars.shtml>

- MARS (Multimedia Analysis and Retrieval System)
- University of Illinois at Urbana-Champaign, University of California at Irvine,
- Demos <http://www-db.ics.uci.edu/pages/demos/index.shtml>.

Example Terrain Region Similarity
Select a region from the image

Terrain similarity matching - Query Results
Click on image to zoom or Start over

Simplicity

http://wang16.ist.psu.edu/cgi-bin/zwang/regionsearch_show.cgi

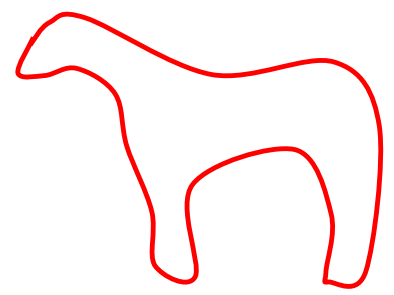
- Stanford university
- 200 000 images
- Similarity



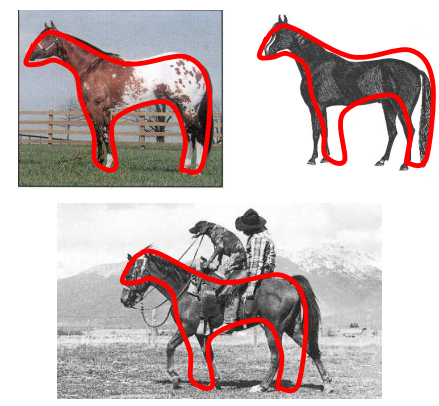
6.3.2 – Retrieval based on shape

- The user gives, for instance gives a shape manually draught (template)
- Comparison with other images
- Linear deformations
 - translations
 - rotations
 - scaling
- Other transformations (warping)

Example “horse”



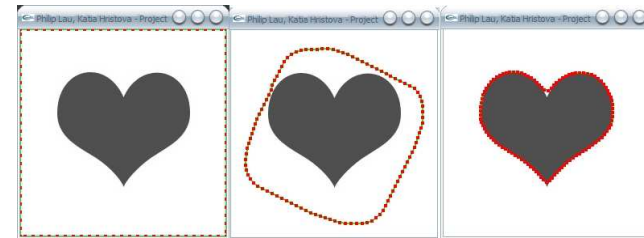
Example of results



Snakes – Active Contours

- Original shape is deformed to reach gradually some other shape
- Objectives
 - To follow edges the best possible
 - To minimize deformation energy

Example



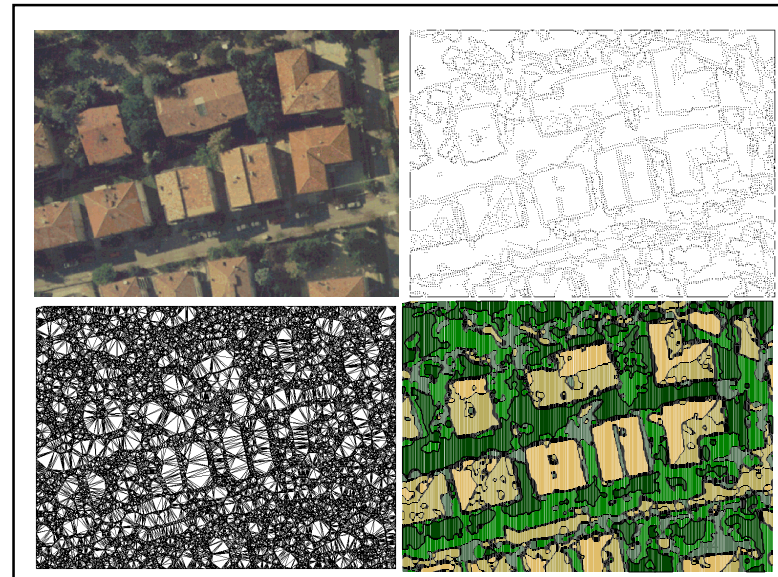
Shape deformation

- Intrinsic equation of the curve

$$\vec{\phi}(s) = \vec{\tau}(s)\vec{\theta}(s)$$

- Measure of deformation

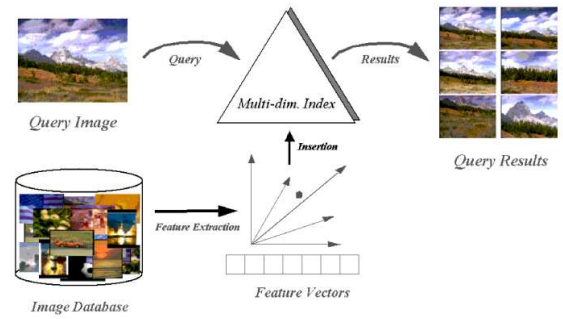
$$M = \int_0^1 [\nabla I(\vec{\phi}(s))]^2 ds$$



6.3.3 – Retrieval based on parameters

- Principle :
 - each image is described by a set of parameters issued from image processing
 - until several dozens of parameters
 - → index (feature extraction)
 - the image-query is analyzed to evaluate those parameters
 - comparison (distance)

Structure



Usual features

$$\begin{aligned}
 f_i &= \text{Energy} = \sum_{i,j} f(i,j)^2, \\
 f_e &= \text{Entropy} = - \sum_{i,j} f(i,j) \log f(i,j), \\
 f_c &= \text{Correlation} = \frac{\sum_{i,j} (i - \mu_i)(j - \mu_j) f(i,j)}{\sigma_i \sigma_j}, \\
 f_d &= \text{Inverse Difference Moment} = \sum_{i,j} \frac{1}{1 + (i-j)^2} f(i,j), \\
 f_s &= \text{Inertia} = \sum_{i,j} (i-j)^2 f(i,j), \\
 f_{cs} &= \text{Cluster Shade} = \sum_{i,j} ((i - \mu_i) - (j - \mu_j))^2 f(i,j), \\
 f_{cp} &= \text{Cluster Prominence} = \sum_{i,j} ((i - \mu_i) - (j - \mu_j))^4 f(i,j), \\
 \text{where } \mu_i &= \sum_j i \sum_j f(i,j), \\
 \mu_j &= \sum_i j \sum_i f(i,j), \\
 \sigma_i &= \sqrt{\sum_i (i - \mu_i)^2 \sum_i f(i,j)}, \\
 \sigma_j &= \sqrt{\sum_j (j - \mu_j)^2 \sum_j f(i,j)}, \\
 f_{cc} &= \text{Pearson's Correlation} = \frac{\sum_{i,j} (i-j) f(i,j) - \mu_x \mu_y}{\sigma_x \sigma_y}
 \end{aligned}$$

6.3.4 – Retrieval based on spatial relations

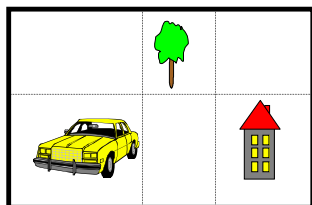
- Symbolic Projections (2D strings)
- Using Egenhofer relations
- Using Jungert operators
- Signature

Chang 2D strings

- Principle :

x-projection : car < tree < house

y-projection : car and house < tree



Description of an image

<i>d</i>		
	<i>b</i>	<i>c</i>
<i>a</i>	<i>a</i>	

- $I = (u, v)$
- $(a=d < a=b < c, a=a < b=c < d)$
- = same place
- < left-right
- normal 2D strings : $(ad < ab < c, aa < bc < d)$

Pattern matching

Initial Image

<i>d</i>		
	<i>b</i>	<i>c</i>
<i>a</i>		

Example of queries :

	<i>b</i>
<i>a</i>	

	<i>c</i>
<i>a</i>	

<i>b</i>	<i>c</i>
<i>a</i>	

Conclusion about 2 D strings

- Interesting tool
- Difficulties of description when overlaps
- Problems of zones with holes (non connected objects)
- ➔ other operators

Encoding with 2D B strings

$u : A_{bx} < B_{bx} = C_{bx} < B_{ex} < A_{ex} < C_{ex}$
 $v : B_{by} < B_{ey} = A_{by} < A_{ey} = C_{by} < C_{ey}$

Jungert operators (1/2)

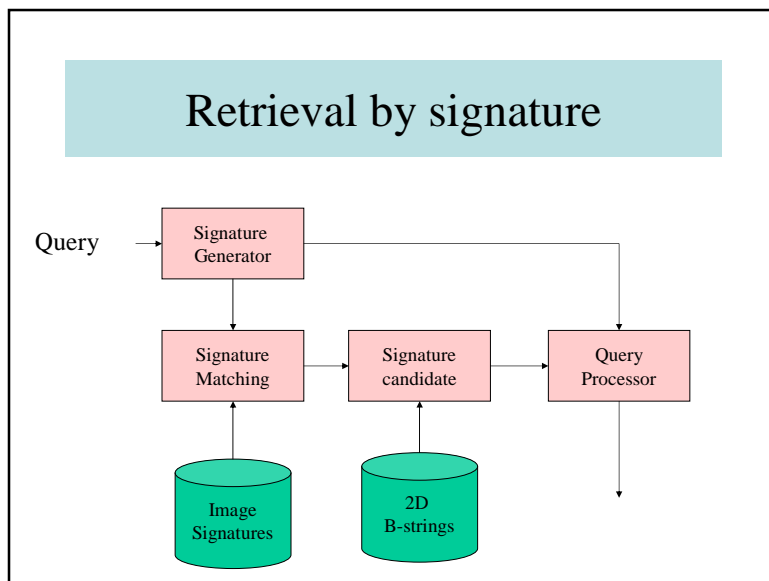
A<B	center(A) < center(B)	
A=B	center(A) = center(B)	
A B	Side by side	
A%B	Min(A) > Min (B) Max(A) < Max (B) Length(A) < Length(B)	

Jungert operators (2/2)

A[B	Min(A) = Min (B) Length(A) < Length(B)	
A]B	Max(A) = Max (B) Length(A) < Length(B)	
A B	Min(A) < Min (B) Length(A) ≤ Length(B)	
A/B	Max(A) > Max (B) Length(A) ≤ Length(B)	

Signature

- 1 – Encoding an image with 2D strings or more exactly with 2D B strings (Lee, Yang, Chen) (= part encodage)
- 2 – Hashing Function



6.4 – Physical Structuring of Image Databases

- Image
 - A set of encoded pixels
 - A set of descriptors (= parameters)
 - Possibly some recognized pictorial objects
- Image Databases
 - Zillions of images (usually same format)
 - An access system based on descriptors
- Big raster
 - A unique very big image (several billions of pixels)
 - Stored position of some pictorial objects

Descriptors

- Descriptors: any characteristics of an image
 - Low level (before interpretation)
 - High level (after interpretation); classifiers
- Several dozens, possibly 100+
- → 1 point in a n -dimension space
- Examples
 - Colors: encoding, histogram, etc.
 - Texture: granularity, direction, repetitiveness, etc.

Query

- Let be a set of descriptors
- Let be a query-image
 - Analysis to evaluate descriptors
- Relevance feedback
 - Several query-images

Relevance feedback

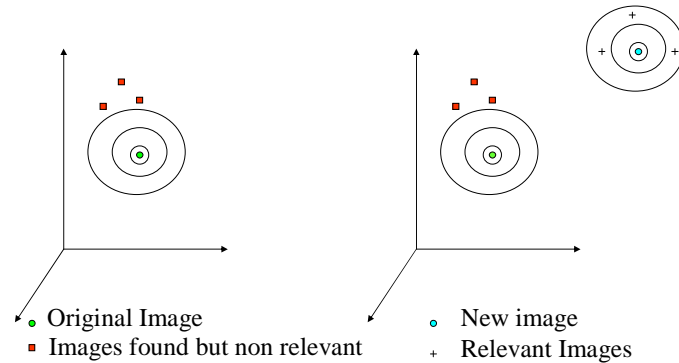


Image query → spatial query

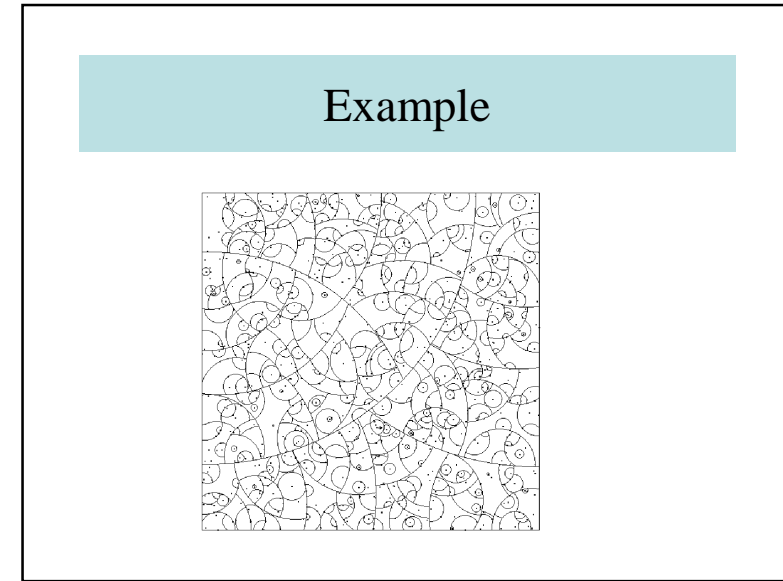
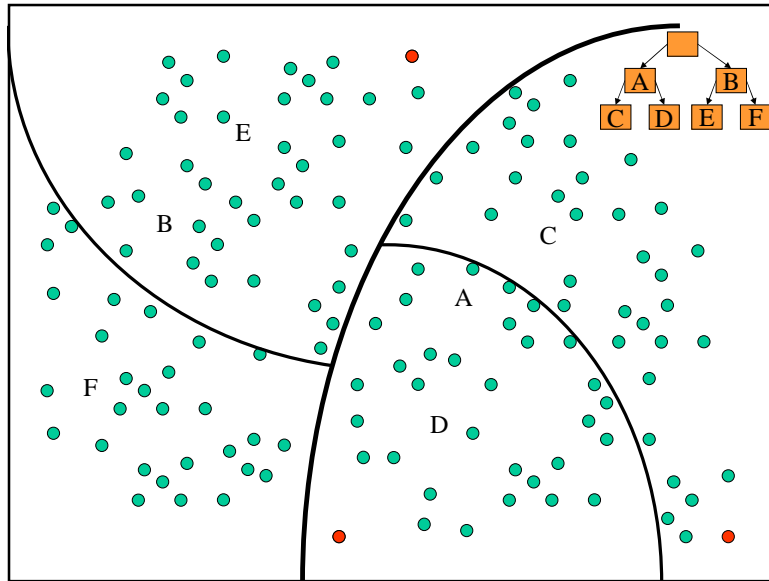
- Point query (n -dimension space)
- Research of k -nearest neighbors
- → Multipoint query

Physical Access Method

- Descriptors → n -dimension space
- Distances
 - Euclidian
 - etc.
- Algorithms: Research of k -nearest neighbors
- Solutions :
 - R-tree or R^+ -tree
 - VP-tree (Vantage Point Tree)

VP-tree

- Retrieval of neighbors
- → distance between points (n -dimension)
- We start from a point (named Vantage point), which will be the center of a "circle" so that 50 % of the points will belong to this "circle"
- Then we continue in a tree-like manner
- Vantage point :
 - barycenter
 - The farthest point



6.5 – Example: Image Rover

- Boston University, MA.
- Demo
<http://www.cs.bu.edu/groups/ivc/ImageRover/demo.html>.
- Semantic Associations
- Color Associations
- Orientation Associations

Semantic Associations

Examples of images expected to be semantically related:

Words surrounding the images are expected to talk about bikes.

Images maynot be semantically related.

Color Associations

Examples of images with similar color composition:



Blue above horizon, but color below horizon varies.



Red in center, surrounded by black.

Orientation Associations

Examples of images with similar distributions of edge orientations:



Dominant vertical edge orientation.



Many edge orientations present; no clear dominant orientation.

6.6 – Conclusion

- Difficulty of retrieving images based on contents
 - Passing from pixels to semantic objects
- Low and high level descriptors
- Dedicated search engines
- Often disappointing results
- Using semantic networks and ontologies

Demos

- <http://wang.ist.psu.edu/IMAGE/>
- <http://www.terraserver.microsoft.com/default.aspx>
- <http://earth.google.com>