

Content-Based Image Retrieval



- Queries
- Commercial Systems
- Retrieval Features
- Indexing in the FIDS System
- Lead-in to Object Recognition



Content-based Image Retrieval (CBIR)

Searching a large database for images that *match* a query:

- What kinds of databases?
- What kinds of queries?
- What constitutes a match?
- How do we make such searches efficient?



Applications

- Art Collections
e.g. Fine Arts Museum of San Francisco
- Medical Image Databases
CT, MRI, Ultrasound, The Visible Human
- Scientific Databases
e.g. Earth Sciences
- General Image Collections for Licensing
Corbis, Getty Images
- The World Wide Web
Google, Microsoft, etc



What is a query?

- an **image** you already have
- a rough **sketch** you draw
- a **symbolic description** of what you want
e.g. an image of a man and a woman on
a beach



Some Systems You Can Try

Corbis Stock Photography and Pictures
<http://pro.corbis.com/>

- Corbis ~~sells~~ sold high-quality images for use in advertising, marketing, illustrating, etc. **Corbis was sold to a Chinese company, but Getty images will provide the image sales.**
- Search is entirely by keywords.
- Human indexers look at each new image and enter keywords.
- A thesaurus constructed from user queries is used.



Google Image

- Google Images
<http://www.google.com/imghp>

Try the camera icon.

The logo graphic consists of three overlapping squares: a yellow one at the top left, a red one at the bottom left, and a blue one at the bottom right. A black crosshair is centered over the intersection of the squares.

Microsoft Bing

- <http://www.bing.com/>

Problem with Text-Based Search

- Retrieval for pigs for the color chapter of my book
- Small company (was called Ditto)
- Allows you to search for pictures from web pages



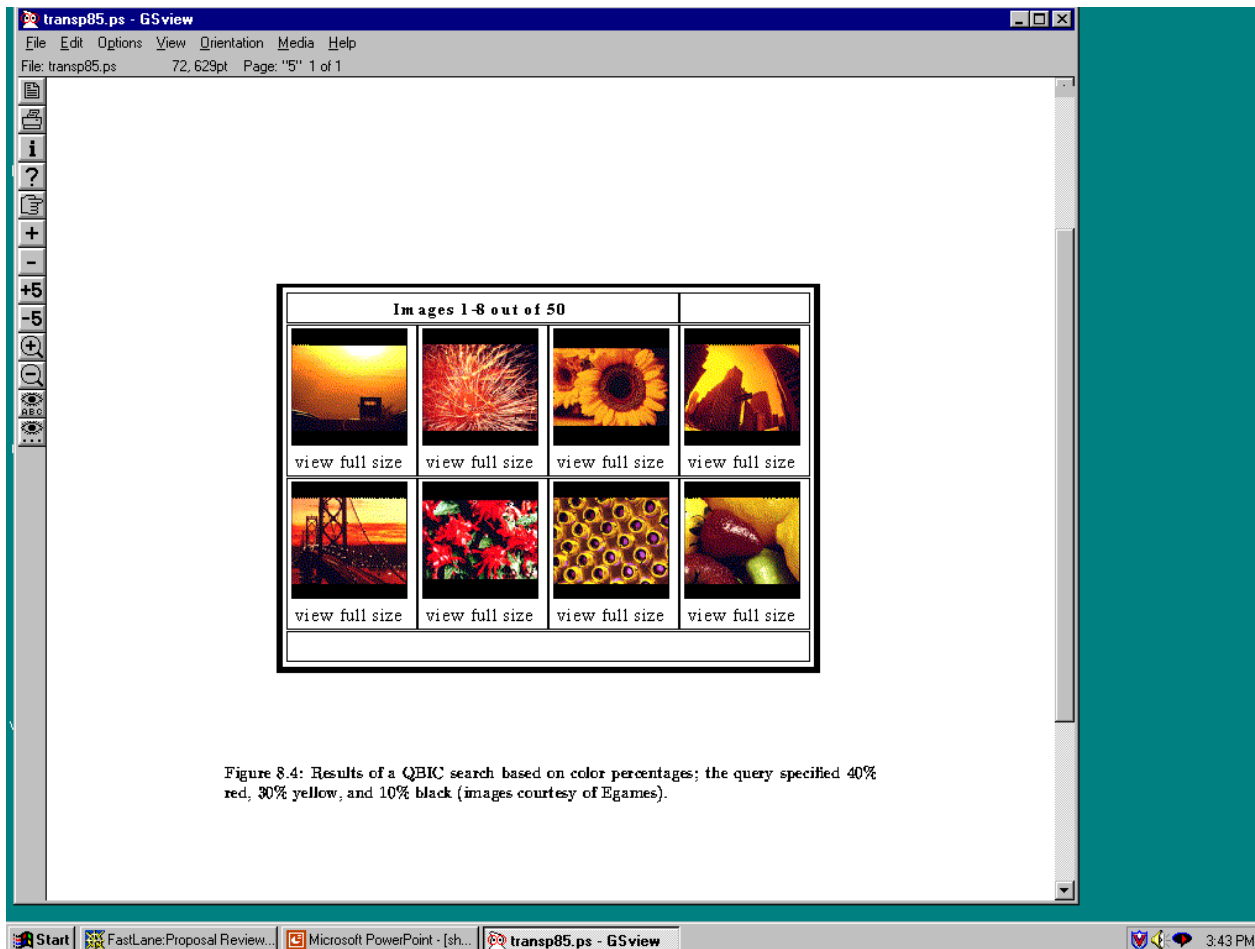


Features

- Color (histograms, gridded layout, wavelets)
- Texture (Laws, Gabor filters, local binary pattern)
- Shape (first segment the image, then use statistical or structural shape similarity measures)
- Objects and their Relationships

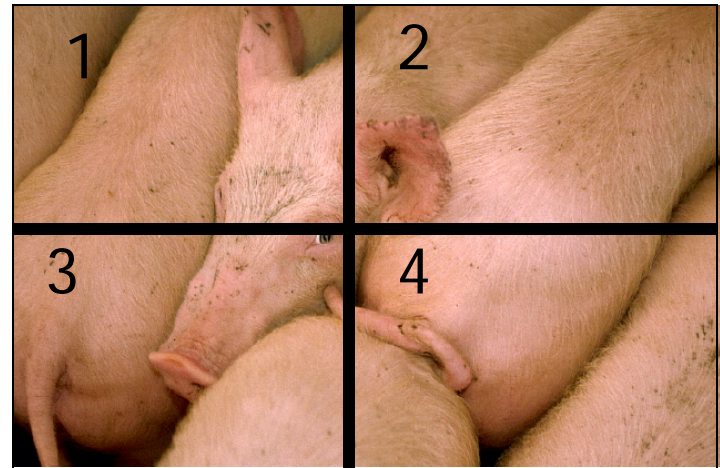
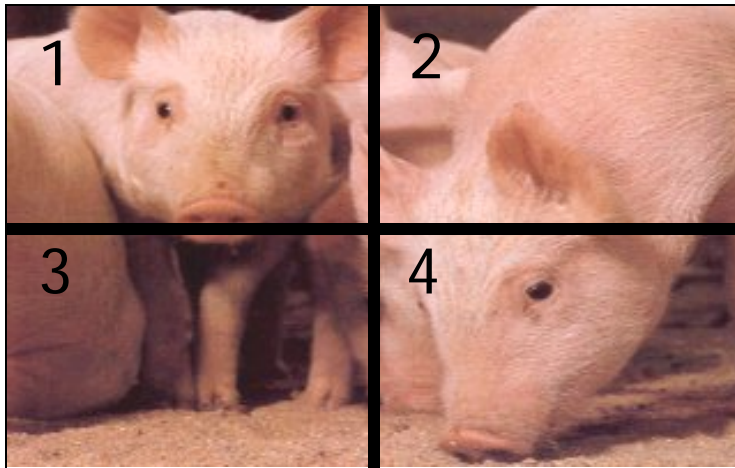
This is the most powerful, but you have to be able to recognize the objects!

Color Histograms



Gridded Color

Gridded color distance is the sum of the color distances in each of the corresponding grid squares.



What color distance would you use for a pair of grid squares?

Color Layout (IBM's Gridded Color)

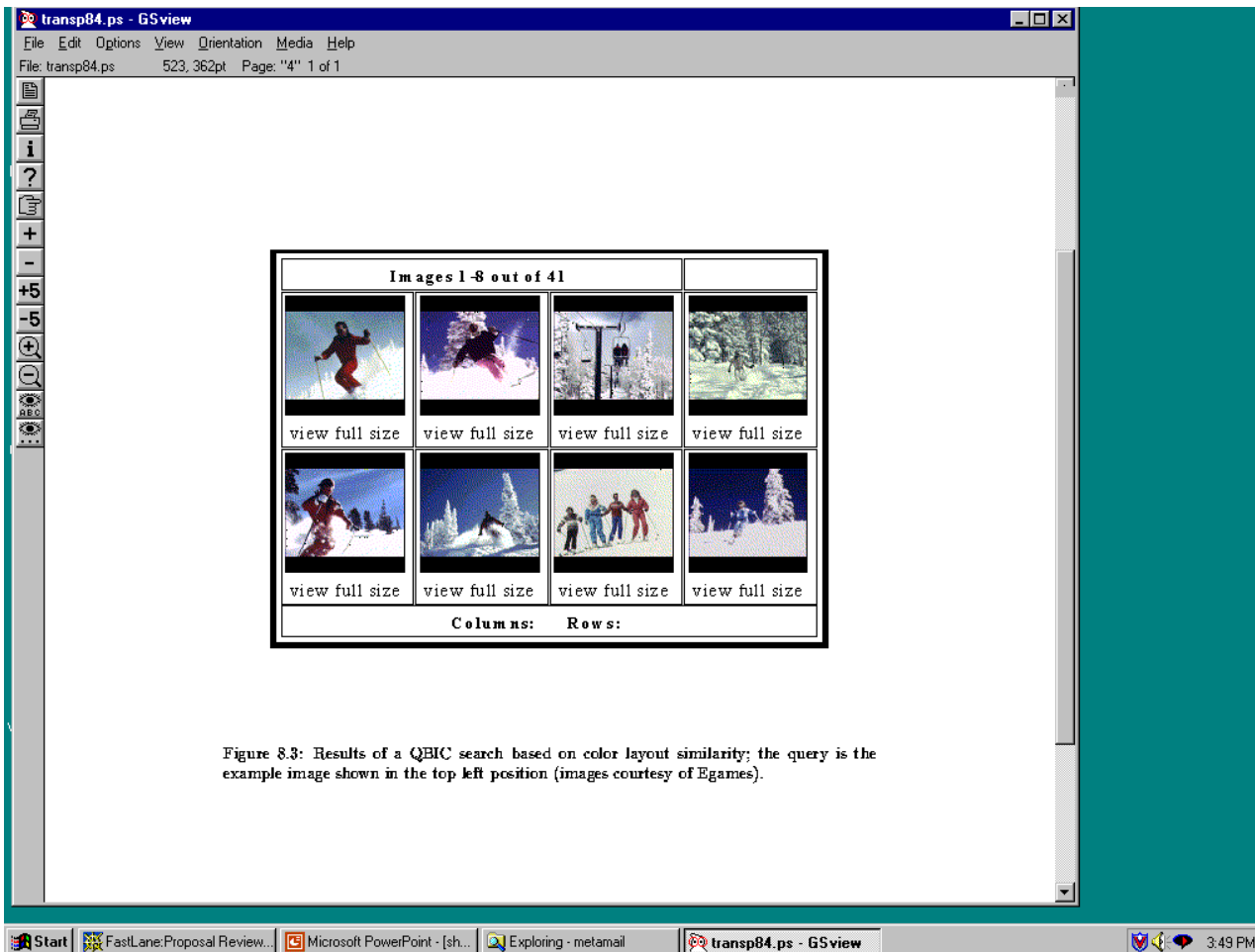


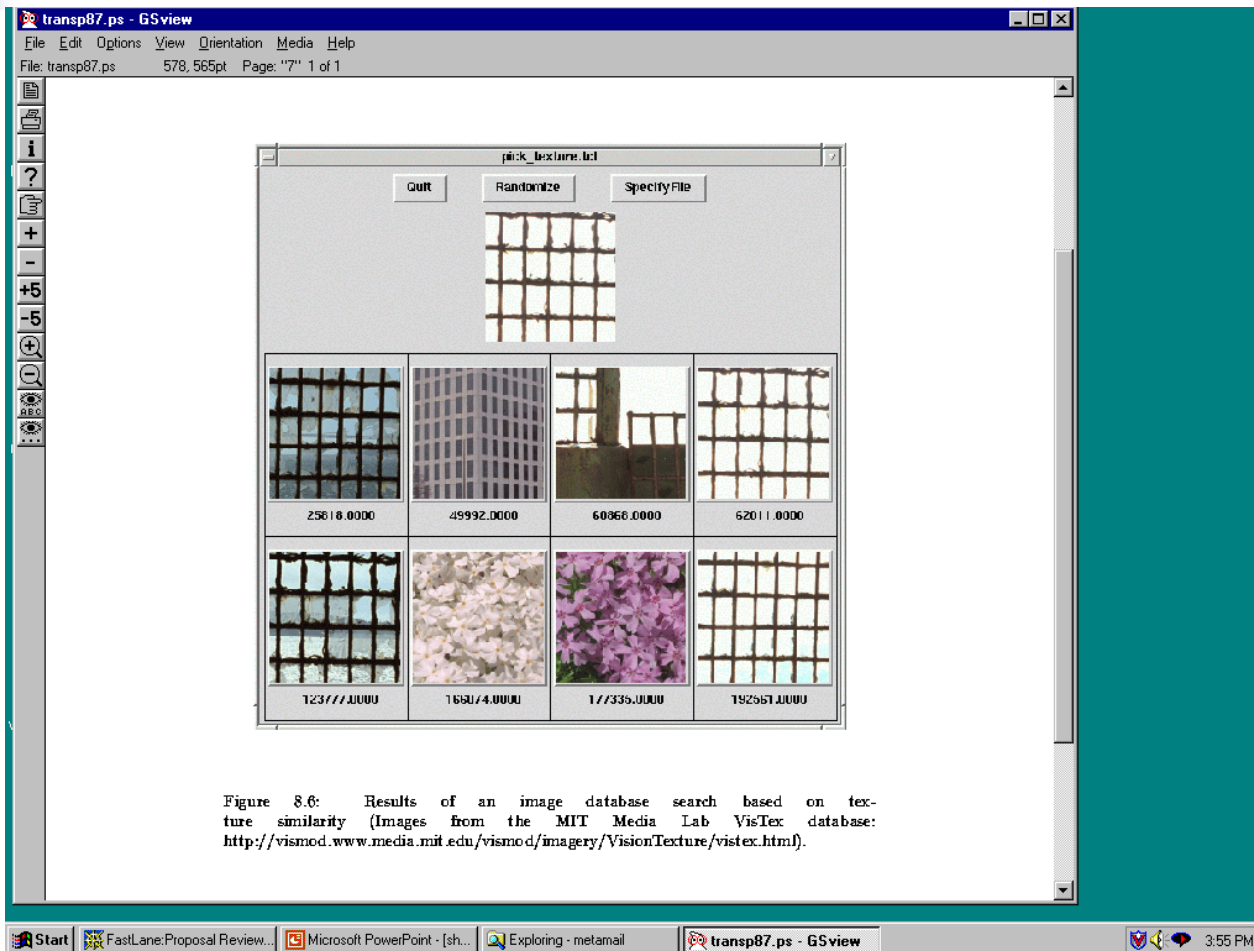
Figure 8.3: Results of a QBIC search based on color layout similarity; the query is the example image shown in the top left position (images courtesy of Egames).



Texture Distances

- Pick and Click (user clicks on a pixel and system retrieves images that have in them a region with similar texture to the region surrounding it).
- Gridded (just like gridded color, but use texture).
- Histogram-based (e.g. compare the LBP histograms).

Laws Texture

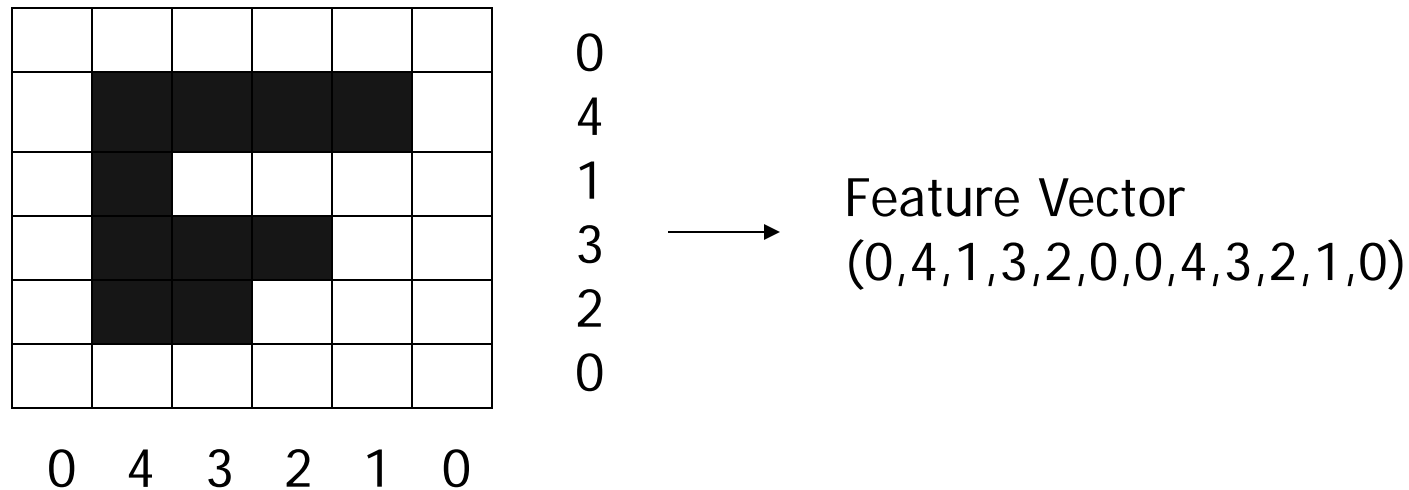




Shape Distances

- Shape goes one step further than color and texture.
- It requires identification of regions to compare.
- There have been many shape similarity measures suggested for pattern recognition that can be used to construct shape distance measures.

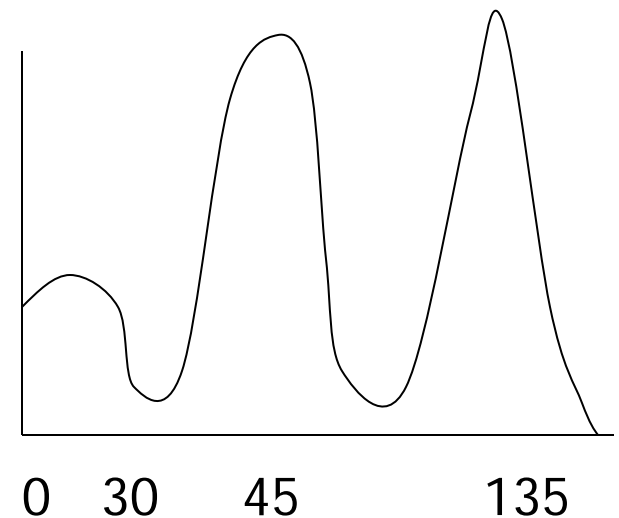
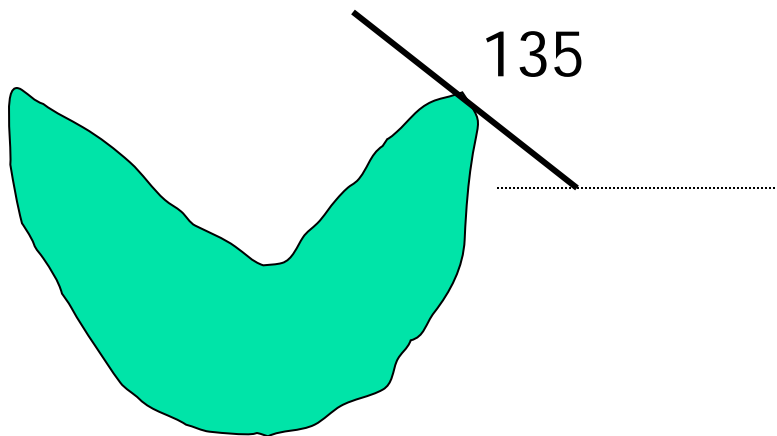
Global Shape Properties: Projection Matching



In projection matching, the horizontal and vertical projections form a histogram.

What are the weaknesses of this method? strengths?

Global Shape Properties: Tangent-Angle Histograms



Is this feature invariant to starting point?
Is it invariant to size, translation, rotation?



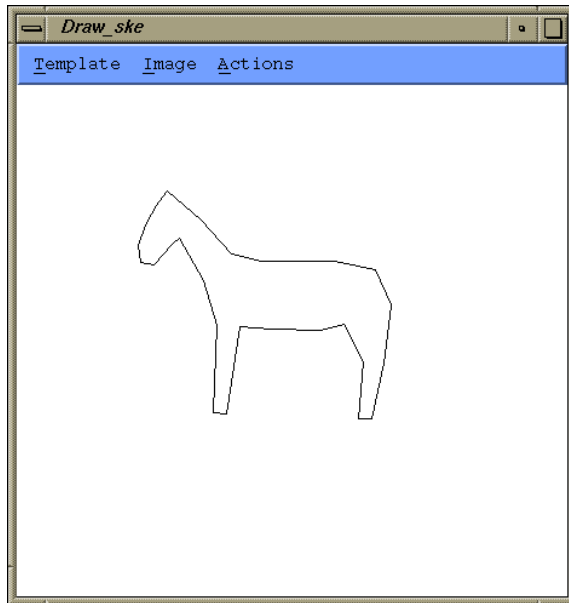
Boundary Matching

- Fourier Descriptors
- Sides and Angles
- Elastic Matching

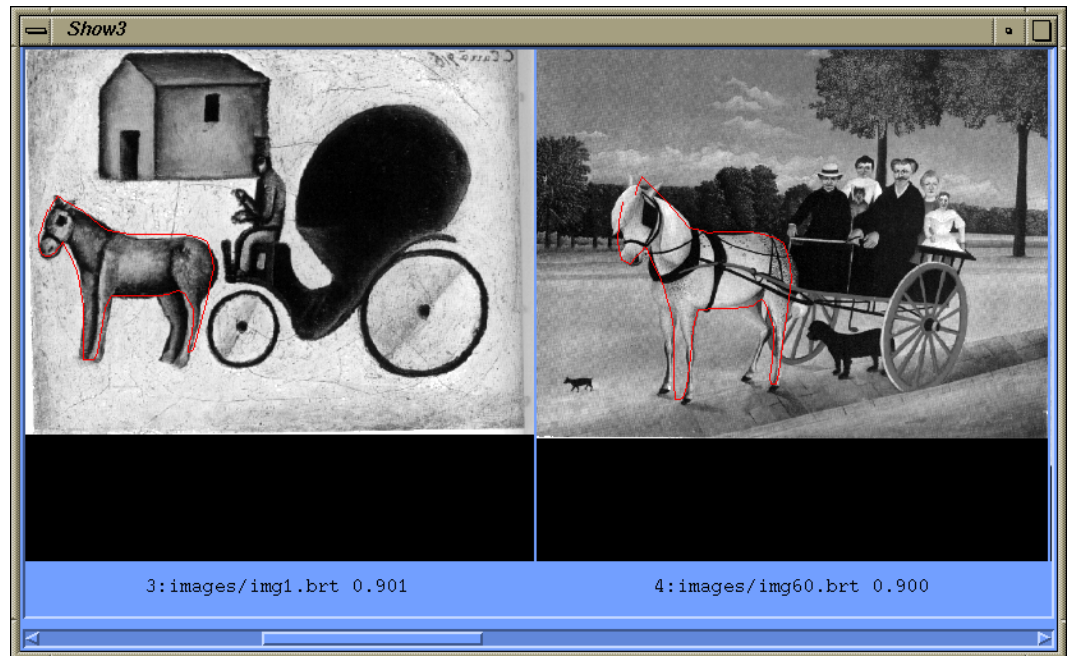
The distance between query shape and image shape has two components:

1. energy required to deform the query shape into one that best matches the image shape
2. a measure of how well the deformed query matches the image

Del Bimbo Elastic Shape Matching



query



retrieved images



Regions and Relationships

- Segment the image into **regions**
- Find their **properties** and **interrelationships**
- Construct a **graph** representation with nodes for regions and edges for spatial relationships
- Use **graph matching** to compare images

Like
what?

Blobworld (Carson et al, 1999)

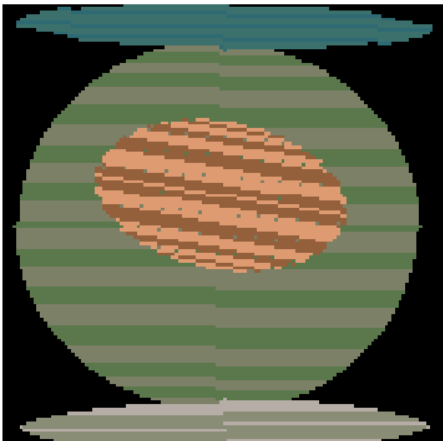


- Segmented the query (and all database images) using EM on color+texture
- Allowed users to select the most important region and what characteristics of it (color, texture, location)
- Asked users if the background was also important

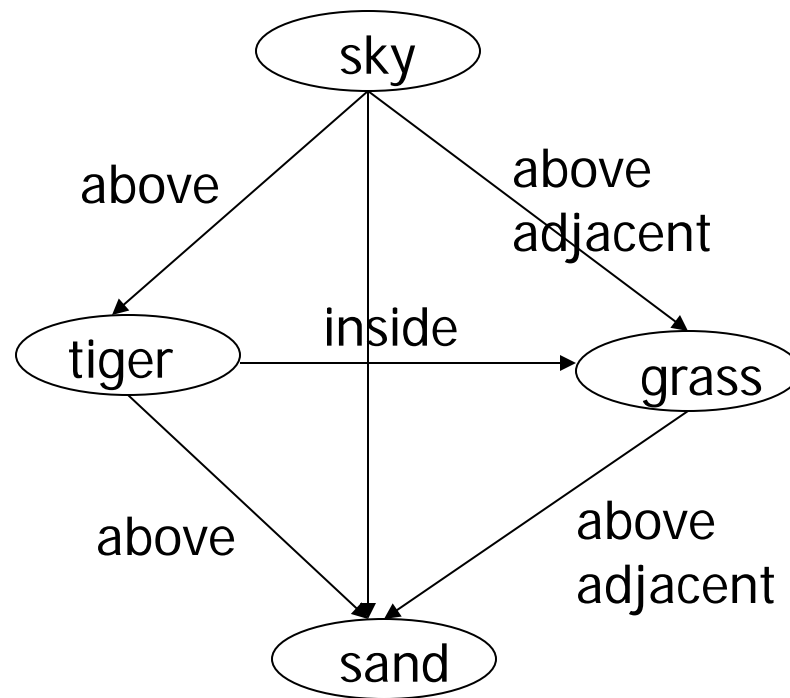
Tiger Image as a Graph (motivated by Blobworld)



image



abstract regions



Andy Berman's FIDS System

multiple distance measures

Boolean and linear combinations

efficient indexing using images as keys

demo: Fids - Netscape

File Edit View Go Communicator Help

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Bookmarks Location: <http://www.cs.washington.edu/research/imedatabase/demo/fids/> What's Related

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Fids demo

Put In Cart

Check Out

Random Go ZoomIn Found 51 matches. Displaying 1 - 6

distance measures loose ... strict

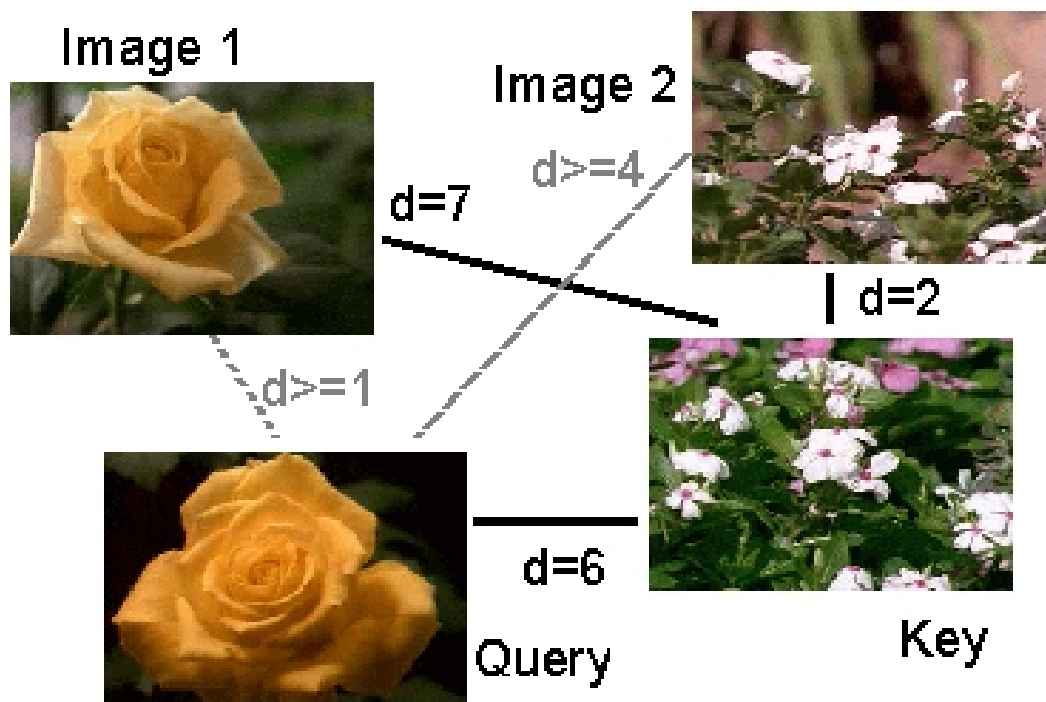
<input type="checkbox"/> ColorHistL14x4x4		5	<input checked="" type="radio"/> And <input type="radio"/> Or <input type="radio"/> Sum
<input checked="" type="checkbox"/> ColorHist8x8x8		5	
<input type="checkbox"/> SobelEdgeHist		5	
<input checked="" type="checkbox"/> LBPHist		5	
<input type="checkbox"/> fleshiness		5	
<input type="checkbox"/> Wavelets		5	

A double click on an image means:
 Set query / Go
 Zoom in

Start demo: Fids - Netscape 10:38 AM

Andy Berman's FIDS System:

Use of **key images** and the **triangle inequality** for efficient retrieval. $d(I,Q) \geq |d(I,K) - d(Q,K)|$



Andy Berman's FIDS System:

Bare-Bones Triangle Inequality Algorithm

Offline

1. Choose a small set of key images
2. Store distances from database images to keys

Online (given query Q)

1. Compute the distance from Q to each key
2. Obtain lower bounds on distances to database images
3. Threshold or return all images in order of lower bounds

Andy Berman's FIDS System:

Flexible Image Database System: Example



An example from our system using a simple color measure.

images in system: 37,748

threshold: 100 out of 1000

images eliminated: 37,729

Andy Berman's FIDS System:

Bare-Bones Algorithm with Multiple Distance Measures

Offline

1. Choose key images for each measure
2. Store distances from database images to keys for all measures

Online (given query Q)

1. Calculate lower bounds for each measure
2. Combine to form lower bounds for composite measures
3. Continue as in single measure algorithm



Demo of FIDS

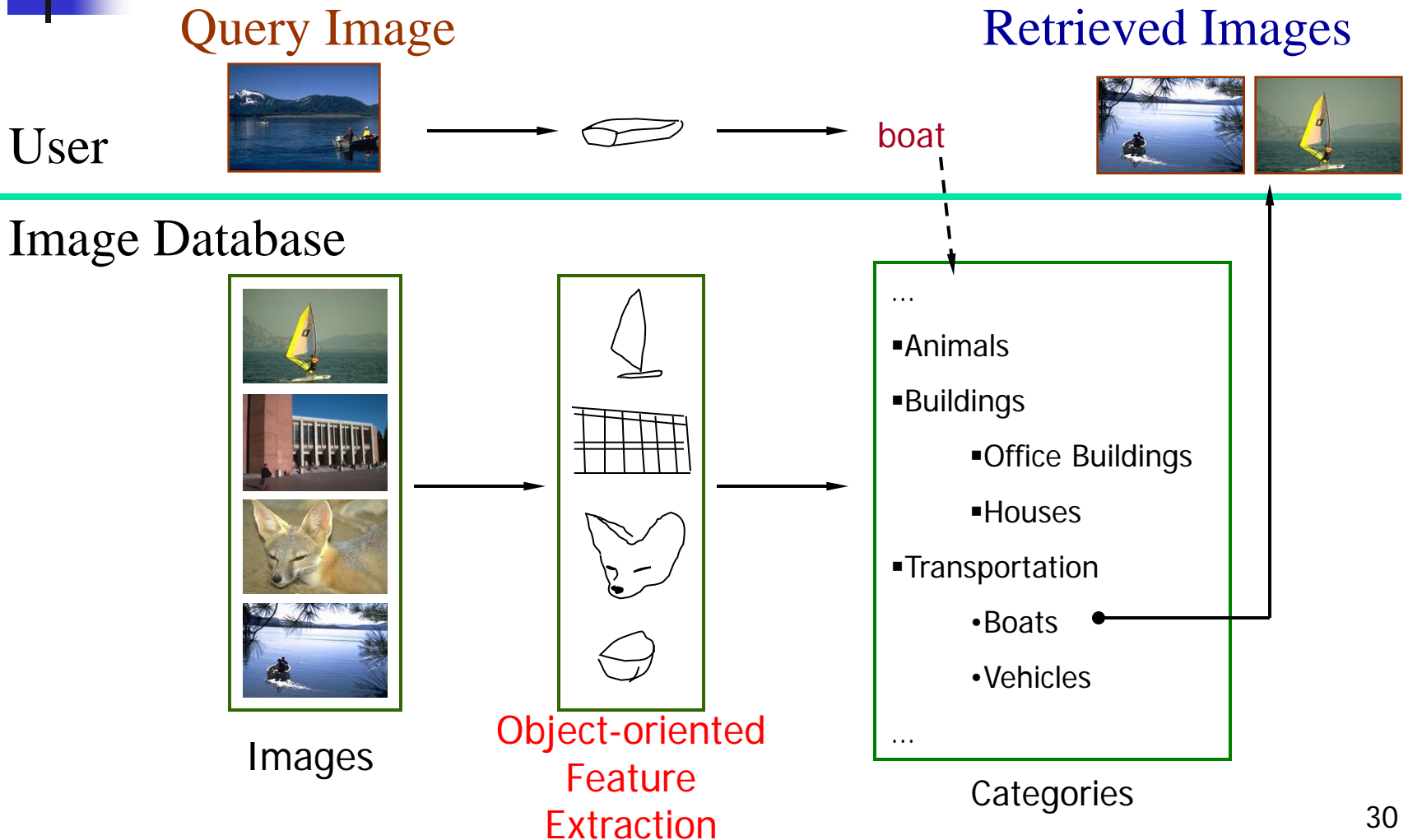
- <http://www.cs.washington.edu/research/imagedatabase/demo/>
- Try this and the other demos on the same page.

Weakness of Low-level Features

- Can't capture the high-level concepts



Research Objective





Overall Approach

- Develop object recognizers for common objects
- Use these recognizers to design a new set of both low- and mid-level features
- Design a learning system that can use these features to recognize classes of objects

Boat Recognition

demo: boat recognition - Netscape

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Bookmarks Location: <http://www.cs.washington.edu/research/imagedatabase/demo/boat/> What's Related

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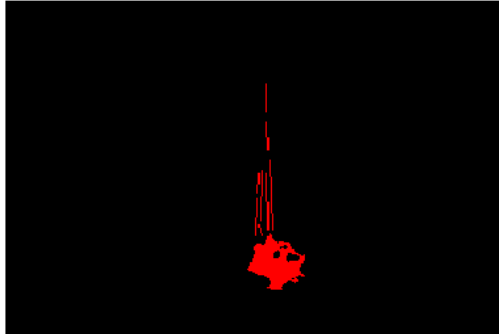
Boat Recognition

1. Select an image: 2. Select a processor: 3. Click

Options:



320*240



(300,12): RGB(0,0,0)

Process done !

- Quick help: **select an Image and a Processor, click the Process button.**
- Processors:
 - *OR_sky*: Sky recognition
 - *OR_sea*: Sea recognition
 - *OR_boat*: Boat recognition
 - *OR_sailboat*: Sailboat recognition

[comments to yi@cs.washington.edu]
Last Modified: Wednesday, December 31, 1969 16:00:00

Start Microsoft PowerPoint - [sh... demo: boat recognitio... 12:03 PM

Vehicle Recognition

demo: Vehicle Recognition - Netscape

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Bookmarks Location: <http://www.cs.washington.edu/research/imagetatabase/demo/cars/> What's Related

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Vehicle Recognition

1. Select an image: 2. Select a processor: 3. Click

Options:

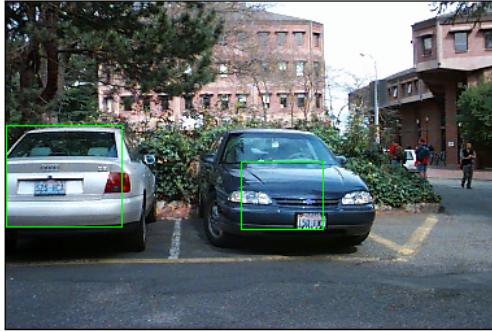
Sigma

Triangle Len



756*504 (682,84): RGB(196,166,174)

Process done!



(586,366): RGB(154,161,153)

- Quick help: **select an Image and a Processor, click the Process button.**
- Processors:
 - *VehicleRecognition*. The final result.
 - *ContourSymmetryCal*. Localize the horizontal position by contour symmetry.
 - *GrayLevelSymmetryCal*. Localize the horizontal position by contour gray-level symmetry.
 - *HorizontalLineSymCal*. Localize the horizontal position by symmetric horizontal line length.
 - *SymmetryFinder*. Localize the horizontal position by voting by the three symmetry-based methods above.
 - *IntensitySymFinder*. Localize the horizontal position by Intensity-based-symmetry. (slow, high resolution)
 - *IntensitySymFinder2*. Localize the horizontal position by Intensity-based-symmetry. (fast, low resolution)
 - *HorizontalEdge*. Localize the horizontal position by Horizontal-edge-based recognition.

Applet CarApplet running

Start Microsoft PowerPoint - [sh... demo: Vehicle Recog...

12:09 PM

Building Recognition

demo: building recognition - Netscape

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Location: http://www.cs.washington.edu/research/imagedatabase/demo/clk_br/

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Building Recognition

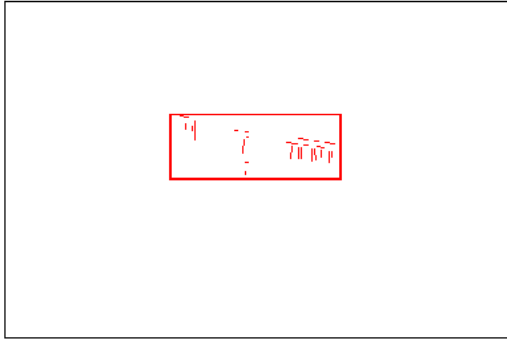
1. Select an image: 2. Select a processor: 3. Click

Options:



640*428 (507,1): RGB(54,146,219)

Process done!



(1,310): RGB(255,255,255)

- Quick help: **select an Image and a Processor, click the Process button.**
- Processors:
 - *CSOSSM_br*: Building recognition by consistent line clusters

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Start Microsoft PowerPoint - [sh...] demo: building recog... 12:12 PM



Building Features: Consistent Line Clusters (CLC)

A **Consistent Line Cluster** is a set of lines that are homogeneous in terms of some line features.

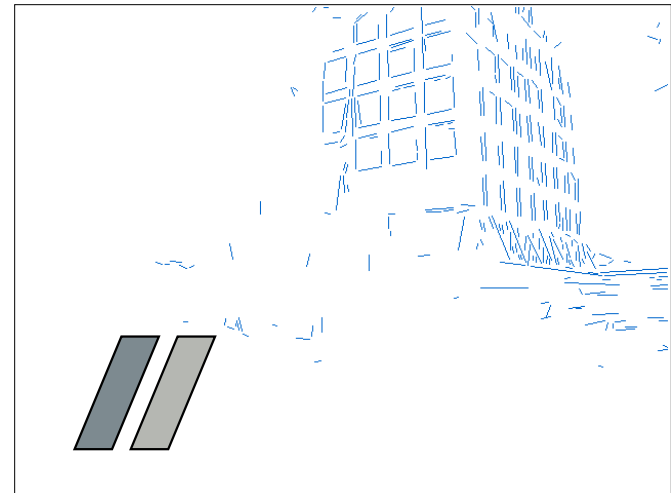
- **Color-CLC**: The lines have the same color feature.
- **Orientation-CLC**: The lines are parallel to each other or converge to a common vanishing point.
- **Spatially-CLC**: The lines are in close proximity to each other.



Color-CLC

- Color feature of lines: **color pair** (c_1, c_2)
- Color pair space:
 - RGB $(256^3 * 256^3)$ Too big!
 - Dominant colors $(20 * 20)$
- Finding the color pairs:
 - One line \rightarrow Several color pairs
- Constructing Color-CLC: **use clustering**

Color-CLC



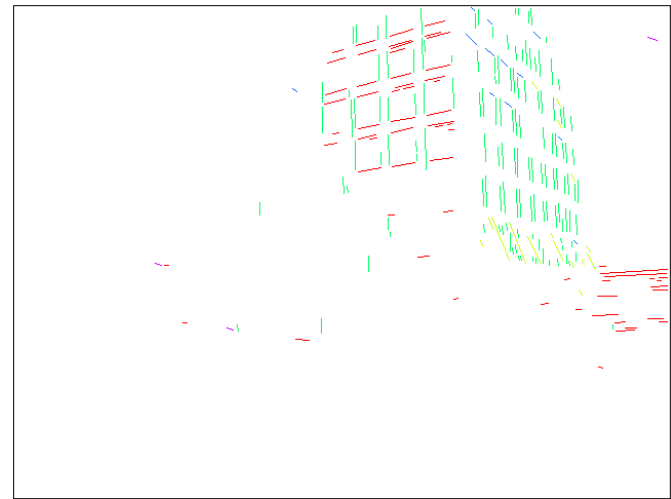
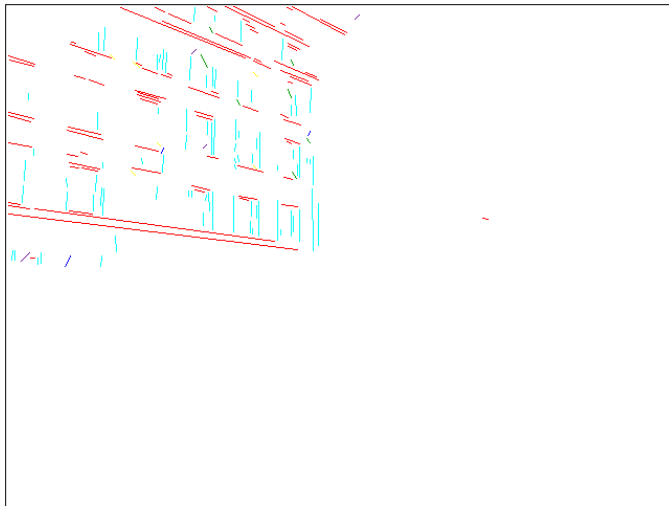


Orientation-CLC

- The lines in an Orientation-CLC are parallel to each other in the 3D world
- The parallel lines of an object in a 2D image can be:
 - Parallel in 2D
 - Converging to a vanishing point (perspective)



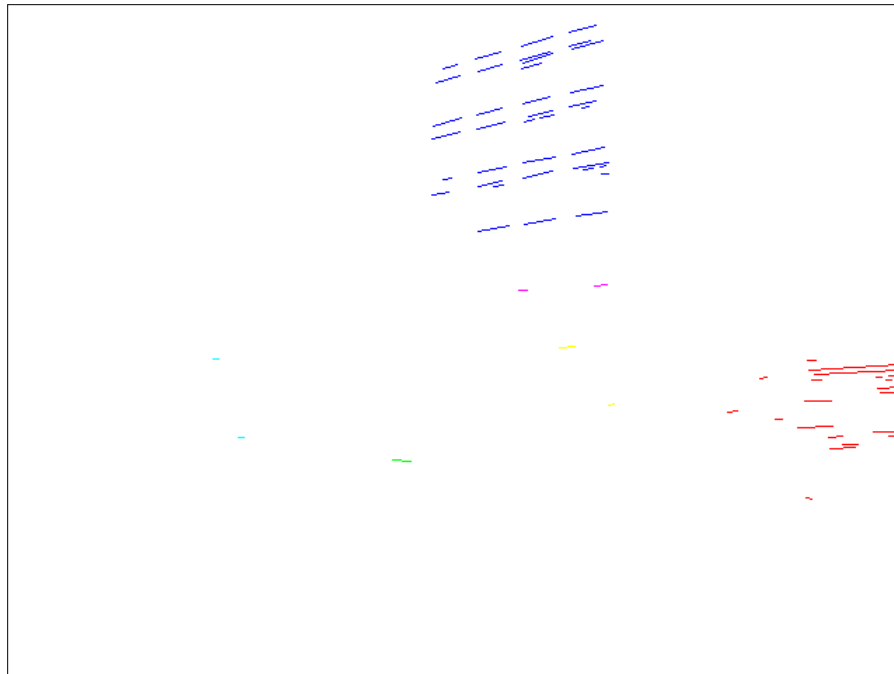
Orientation-CLC





Spatially-CLC

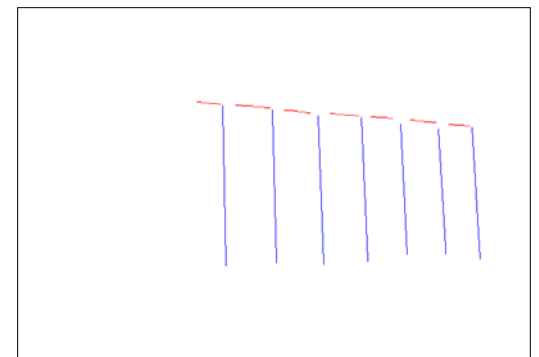
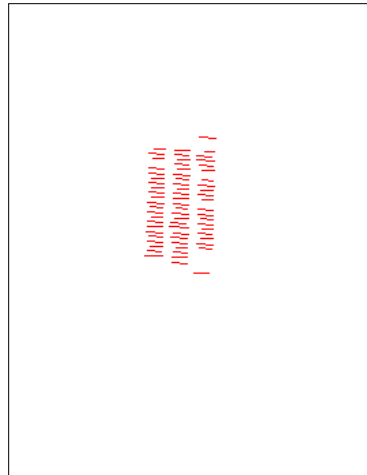
- Vertical position clustering
- Horizontal position clustering



Building Recognition by CLC

Two types of buildings → Two criteria

- Inter-relationship criterion
- Intra-relationship criterion



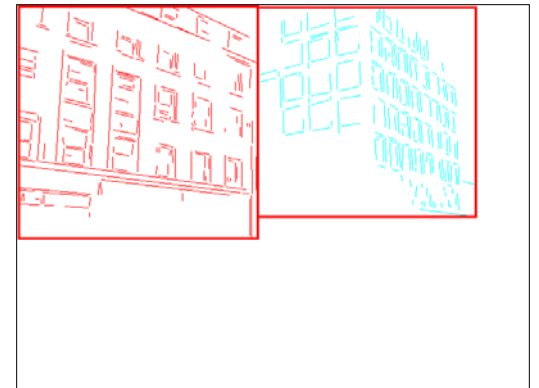
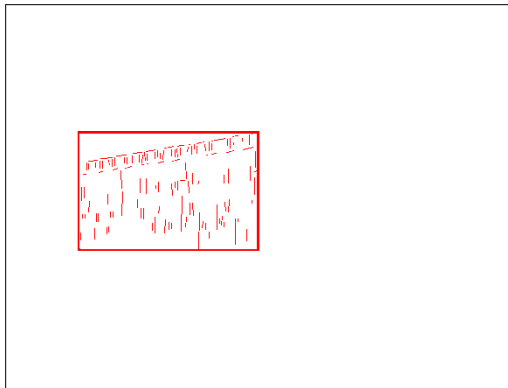
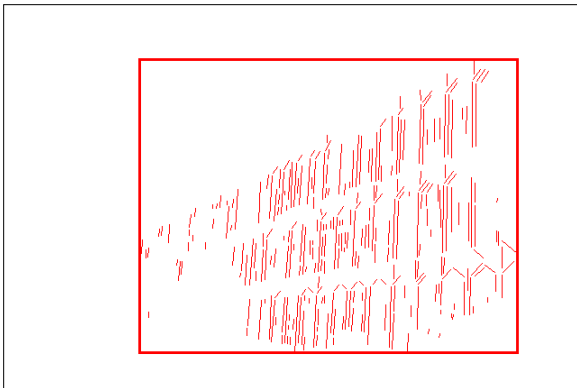


Experimental Evaluation

- Object Recognition
 - 97 well-patterned buildings (bp): 97/97
 - 44 not well-patterned buildings (bnp): 42/44
 - 16 not patterned non-buildings (nbnp): 15/16 (one false positive)
 - 25 patterned non-buildings (nbp): 0/25
- CBIR

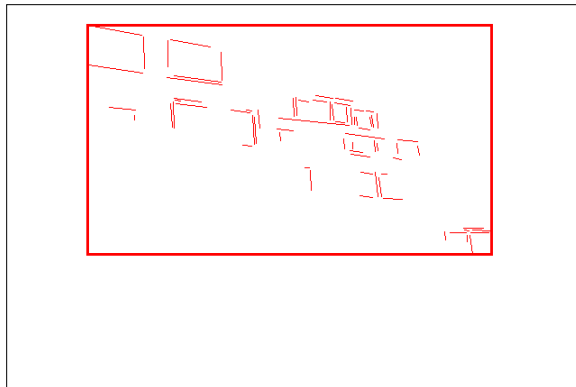
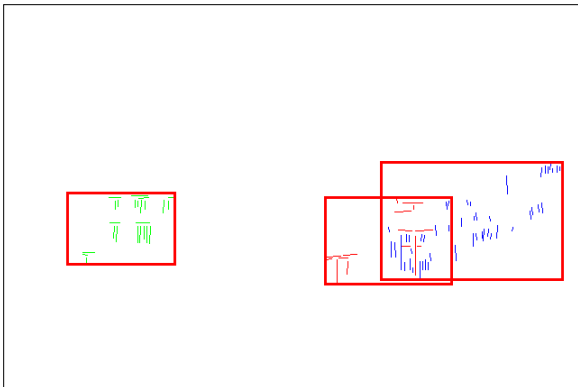
Experimental Evaluation

Well-Patterned Buildings



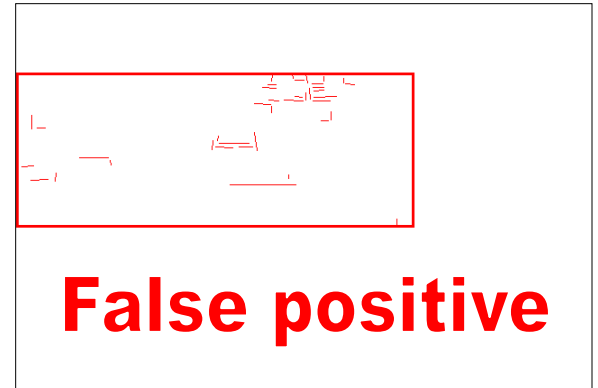
Experimental Evaluation

Non-Well-Patterned Buildings



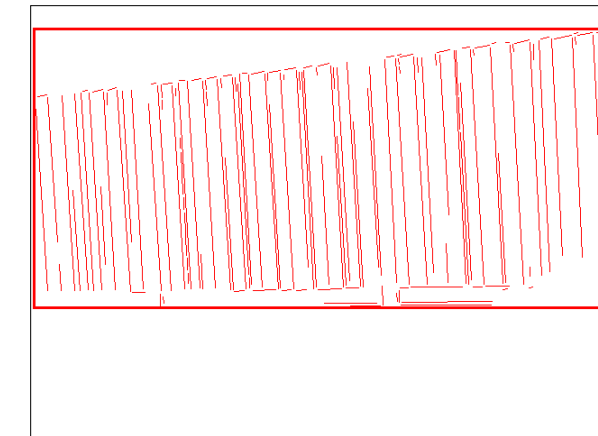
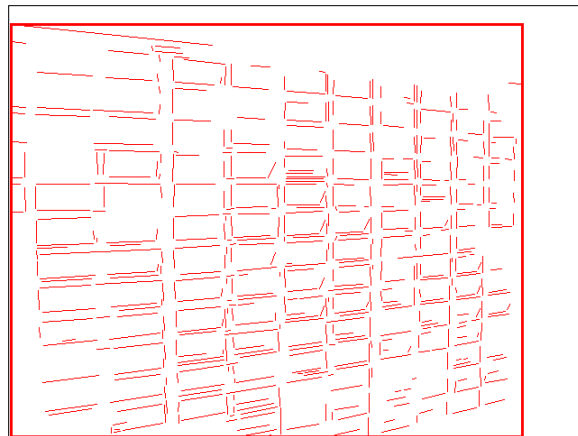
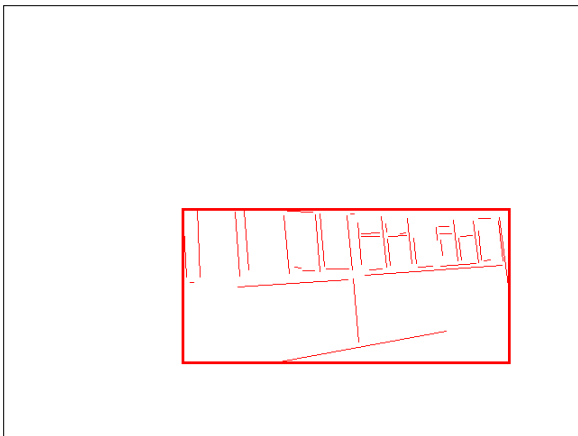
Experimental Evaluation

Non-Well-Patterned Non-Buildings



Experimental Evaluation

Well-Patterned Non-Buildings (false positives)





Experimental Evaluation (CBIR)

	Total Positive Classification (#)	Total Negative Classification (#)	False positive (#)	False negative (#)	Accuracy (%)
Arborgreens	0	47	0	0	100
Campusinfall	27	21	0	5	89.6
Cannonbeach	30	18	0	6	87.5
Yellowstone	4	44	4	0	91.7

Experimental Evaluation (CBIR)

False positives from Yellowstone

