# Image Processing

Empirical Evaluation of Dissimilarity Measures for Color and Texture

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cs160

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# Administrative

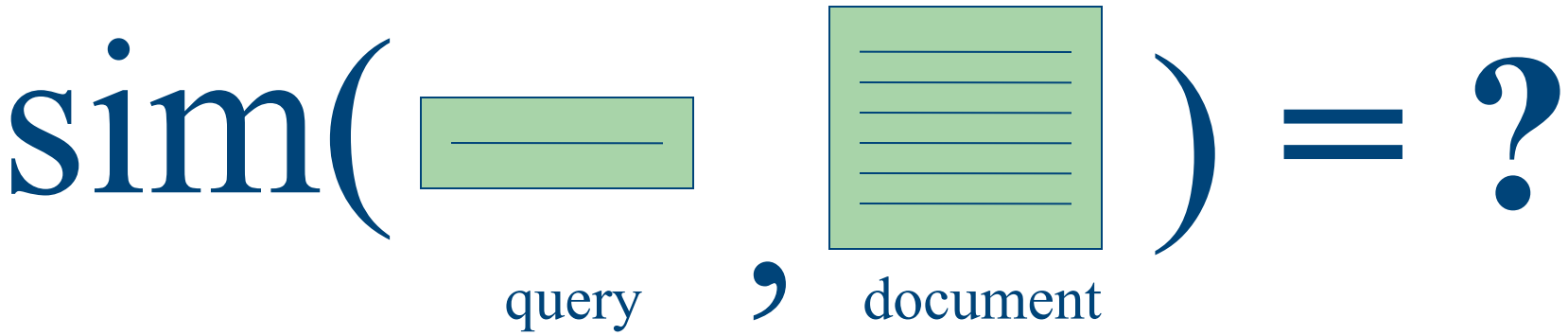
- 11/4 class project discussion
  - project proposal draft due
- 11/5 4:15pm Rose Hill Theatre
- CS Lunch today

# Image processing

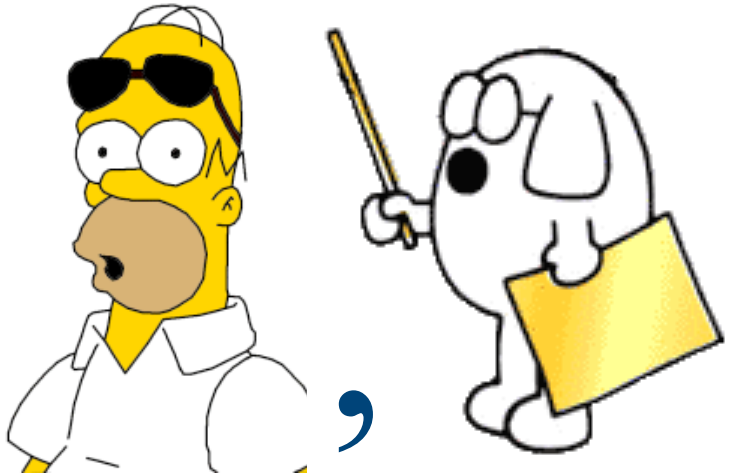
- Image processing
  - http://webcast.berkeley.edu/course_details.php?seriesid=1906978282
- Computer vision
  - http://cseweb.ucsd.edu/classes/sp09/cse252b/
- CVPR
  - http://www.cvpr2009.org/full-program

# Text retrieval

- What was the key problem we needed to solve for text retrieval?



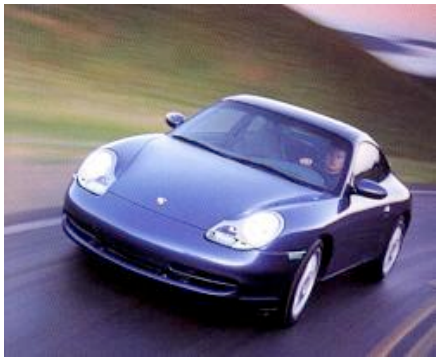
# The Problem: Image Similarity

sim(  ) = ?

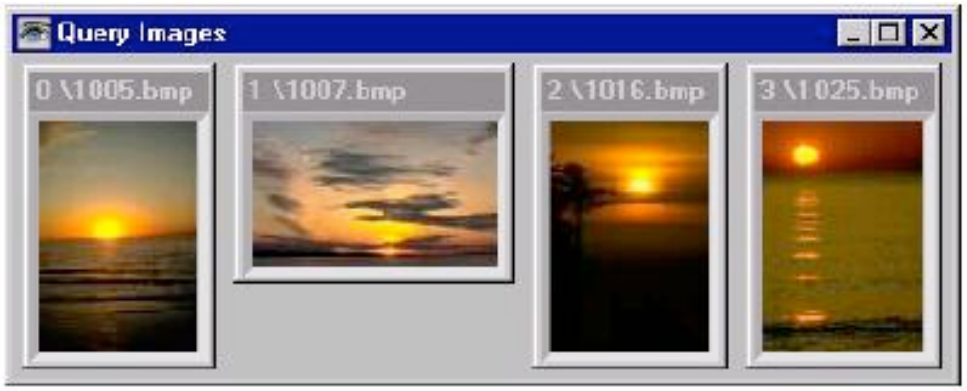
# Where does this problem arise in computer vision?

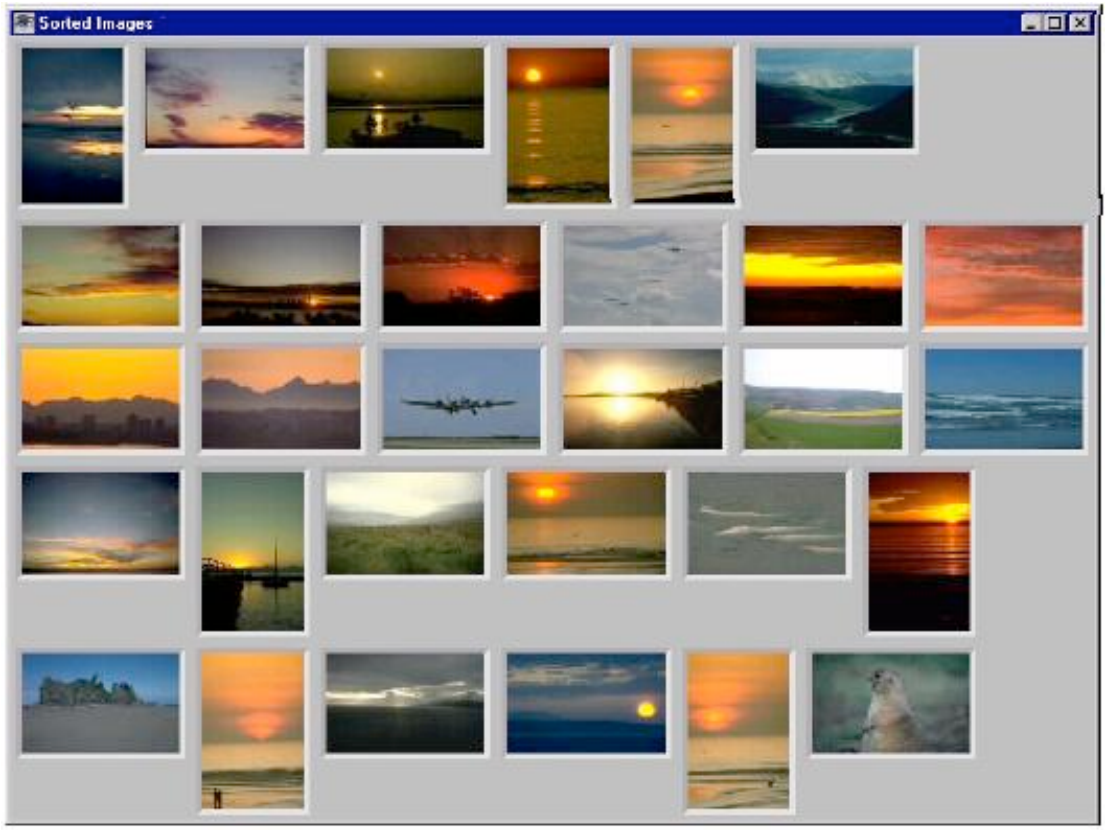
- Image Classification
- Image Retrieval
- Image Segmentation

# Classification

# Retrieval




Jeremy S. De Bonet, Paul Viola (1997). Structure Driven Image Database Retrieval. Neural Information Processing 10 (1997).

# Segmentation

http://vizlab.rutgers.edu/~comanici/segm_images.html

# How is an image represented?

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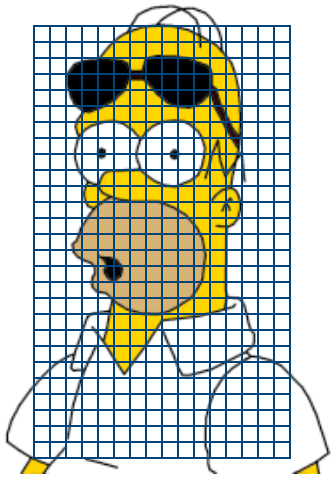
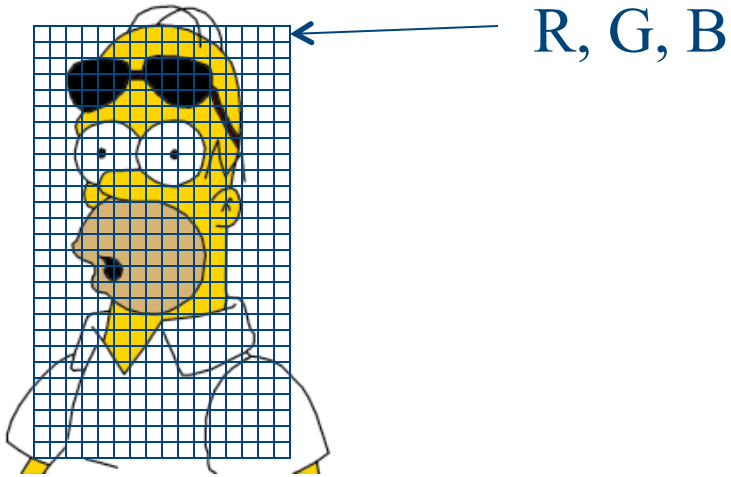


- images are made up of pixels
- for a color image, each pixel corresponds to an RGB value (i.e. three numbers)

# Image file formats

- BitMaP
- JPEG
- TIFF
- Gif
- Png
- …

# Bitmap



# JPEG Compression Process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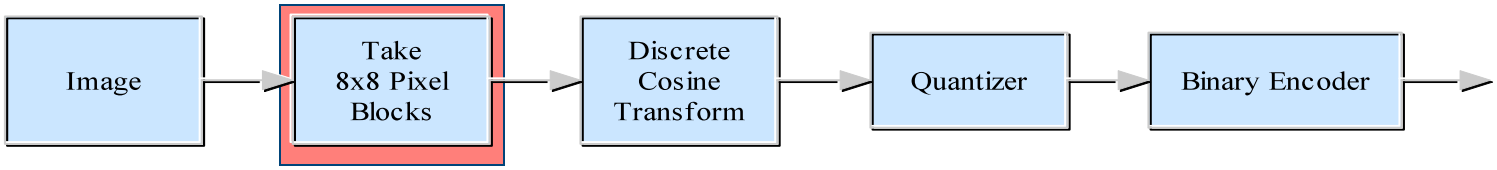


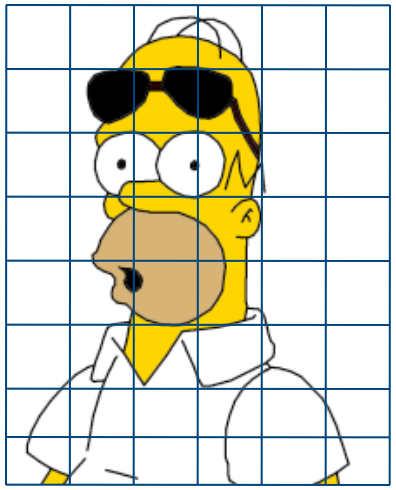

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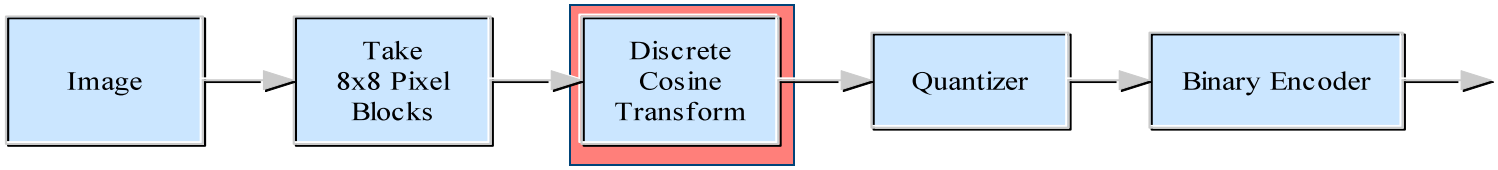


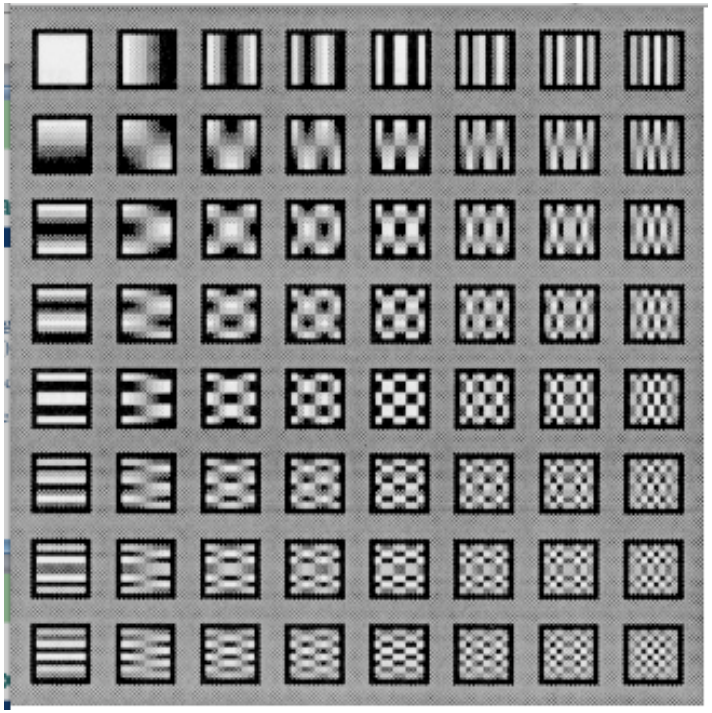

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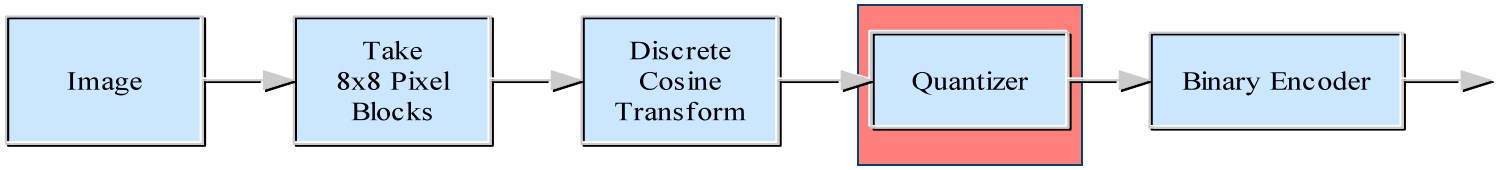
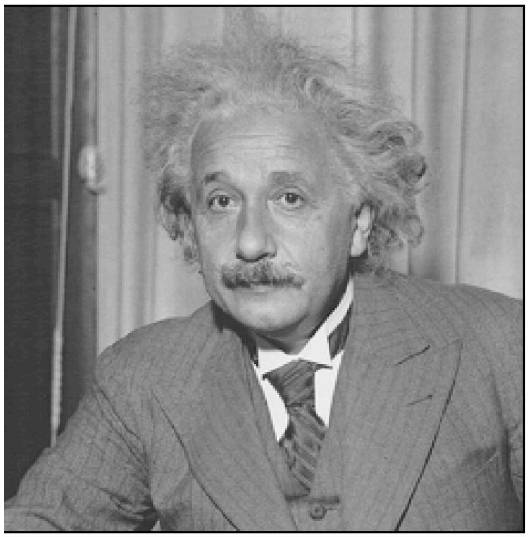


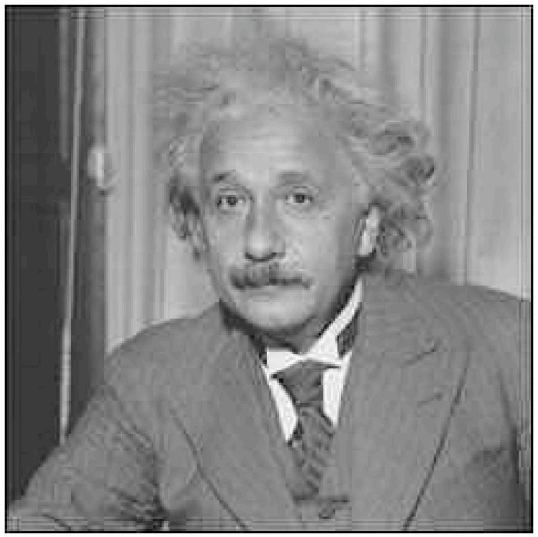

Quantizer: Weights the various spectral coefficients according to their importance, with respect to the human visual system.

# JPEG Compression

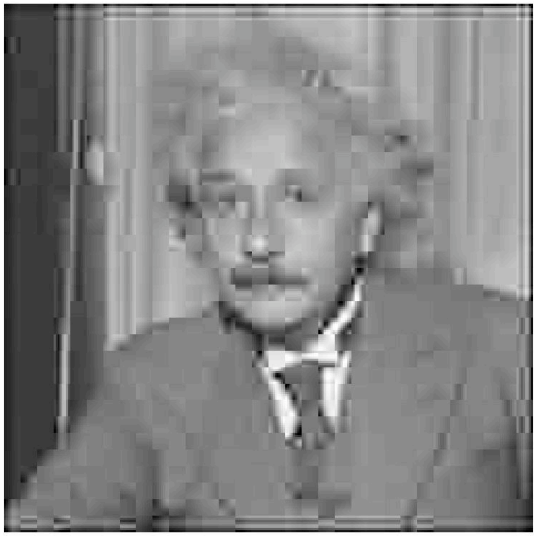
JPEG Image with no Lossy Compression



JPEG Image with Lossy Compression Ratio of ~3



JPEG Image with Lossy Compression Ratio of ~9



# Image features

# Color

Which is more similar?

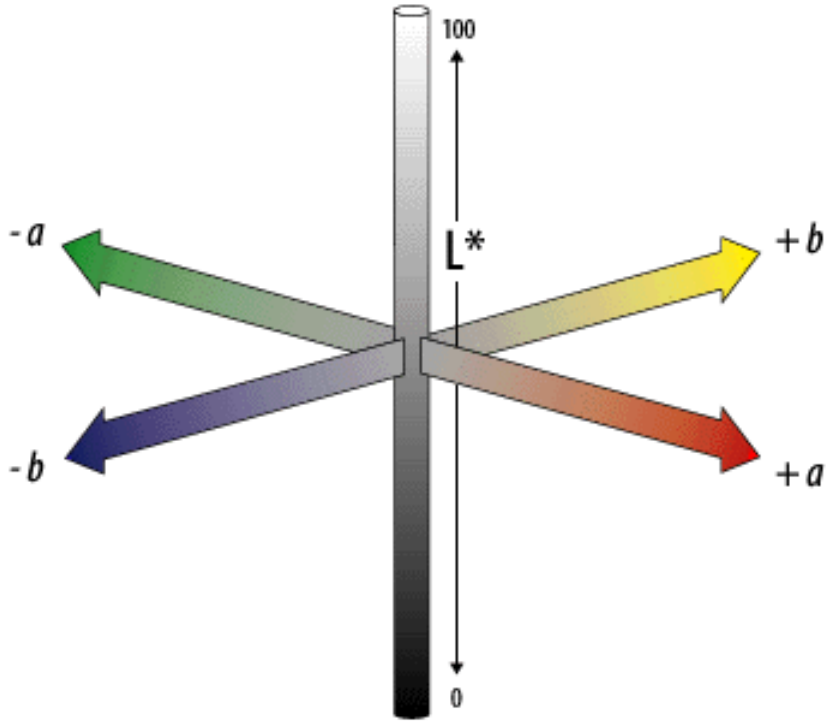
L*a*b* was designed to be uniform in that perceptual “closeness” corresponds to Euclidean distance in the space.

# L*a*b*

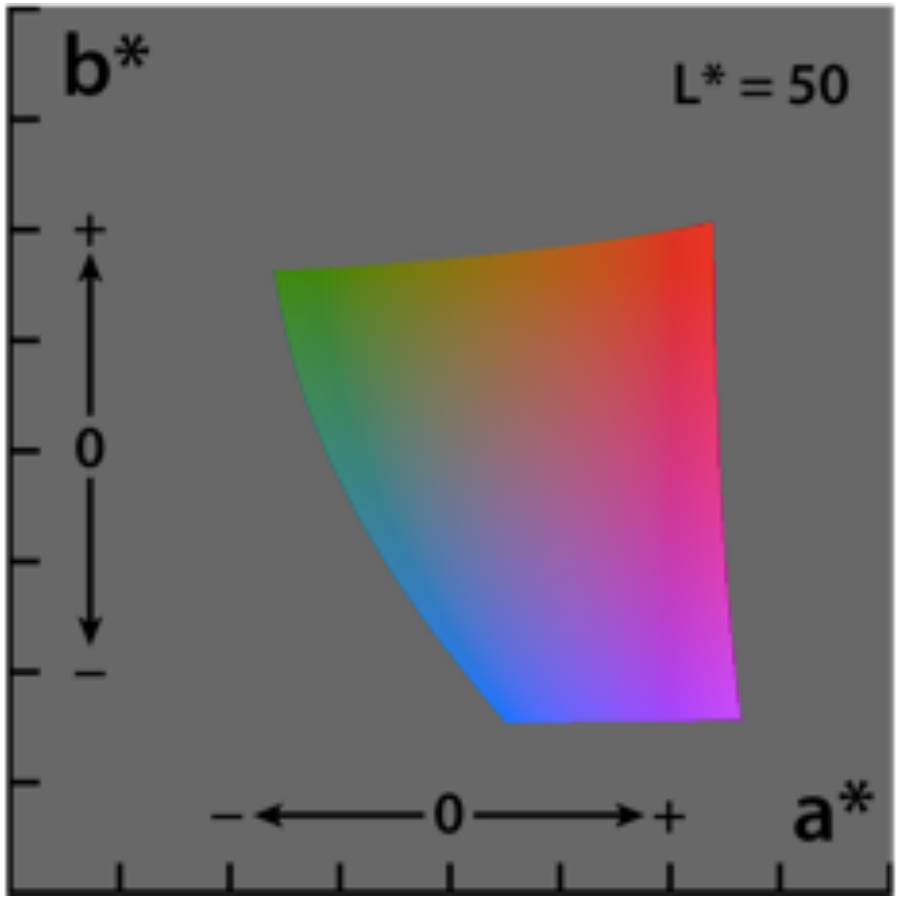
L – lightness (white to black)

a – red-greeness

b – yellowness-blueness

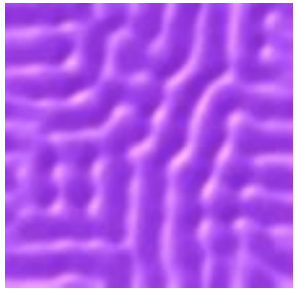


# L*a*b*



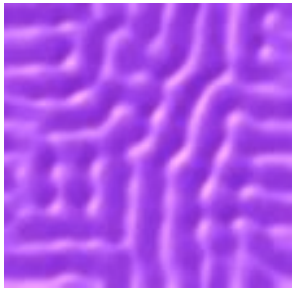
# Texture

How is texture different than color?



# Texture

- Texture is not pointwise like color
- Texture involves a local neighborhood



How can we capture texture?
How did we capture audio texture?

# Gabor Filters

- Gabor filters are Gaussians modulated by sinusoids
- They can be tuned in both the scale (size) and the orientation
- A filter is applied to a region and is characterized by some feature of the energy distribution (often mean and standard deviation)
- Similar idea to wavelets (Gabor wavelet)!

# Examples of Gabor Filters

Scale: 3 at 72°

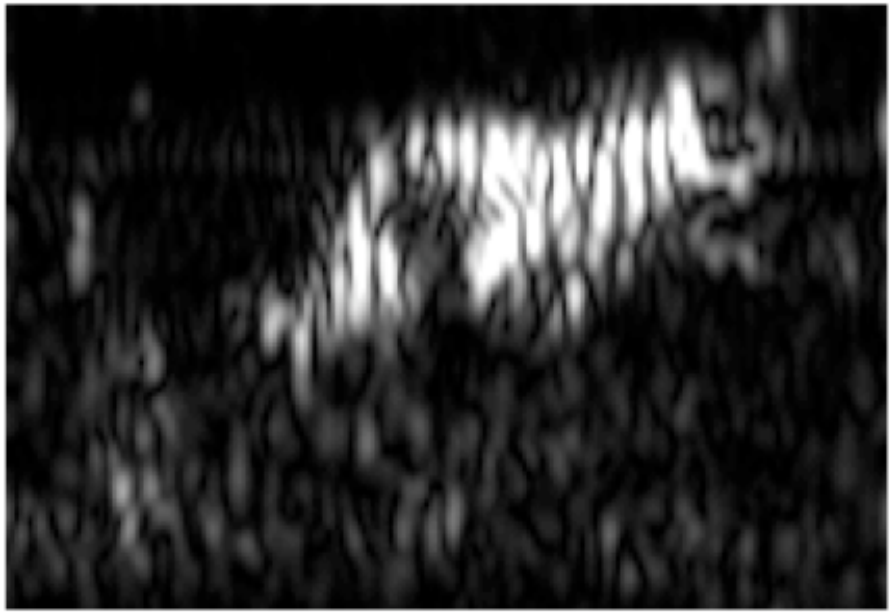
Scale: 4 at 108°

Scale: 5 at 144°

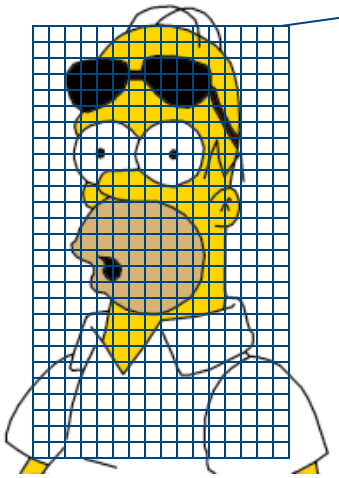
# Gabor filters

What would the response look like to a vertical filter?

# Gabor filters



# Features

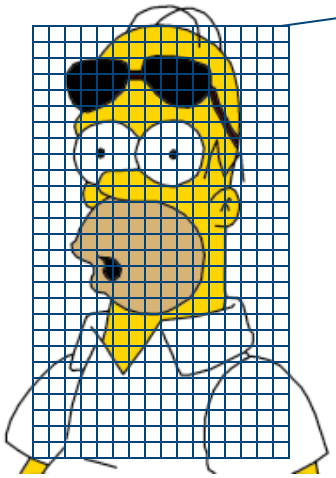


For each pixel:

- set of color features
- set of texture features (i.e. responses to different filters)
- …

any problem?

# Features



For each pixel:

- set of color features
- set of texture features (i.e. responses to different filters)
- …

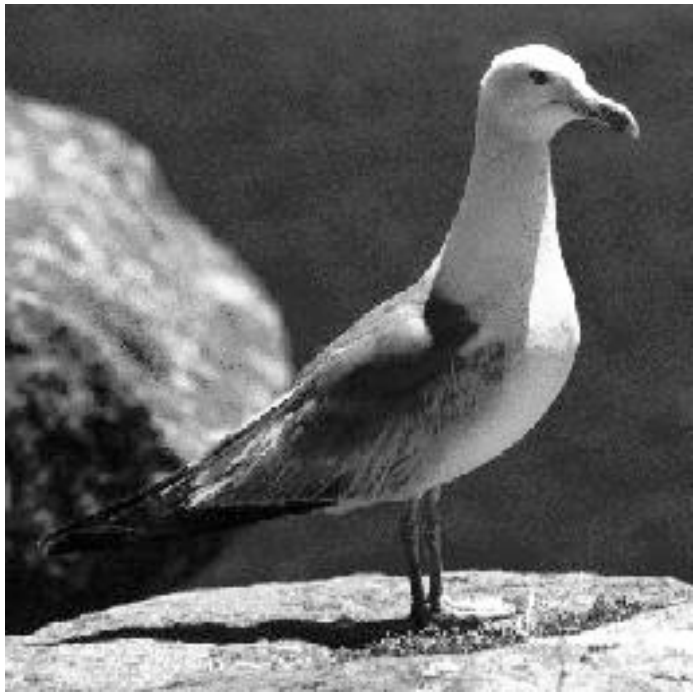
- Lots of features!
- Extremely sparse
- Features are position dependent

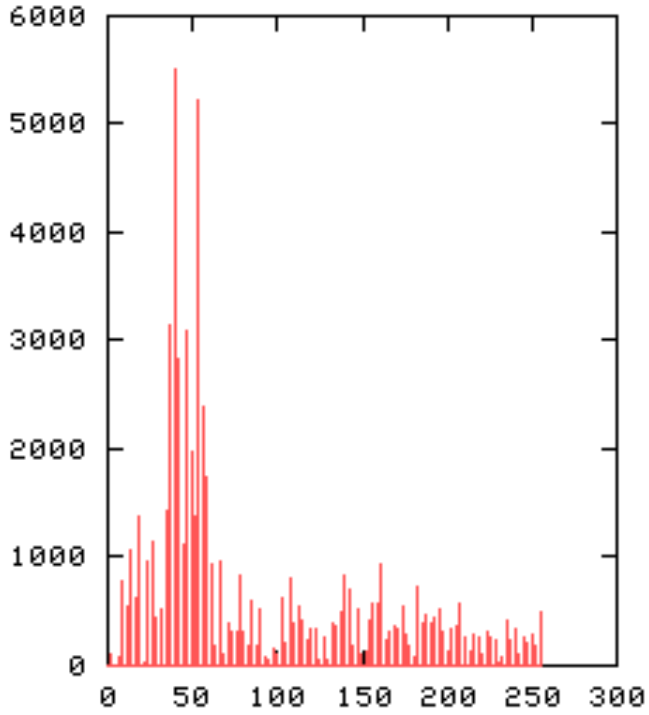
Ideas?

# One approach: histograms

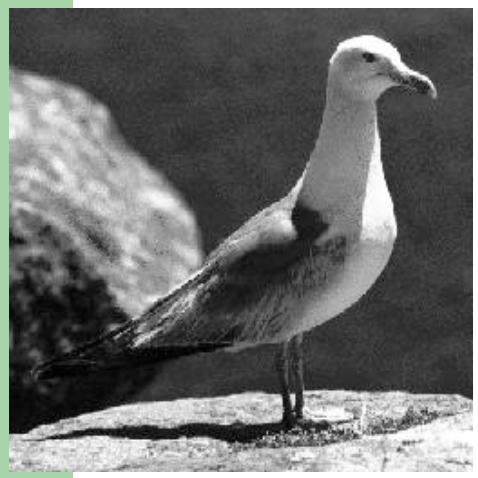
- Examine the distribution of features, rather than the features themselves
- General purpose (i.e. any distribution of features)
- Resilient to variations (shadowing, changes in illumination, shading, etc.)
- Can use previous work in statistics, etc.

# Histogram Example

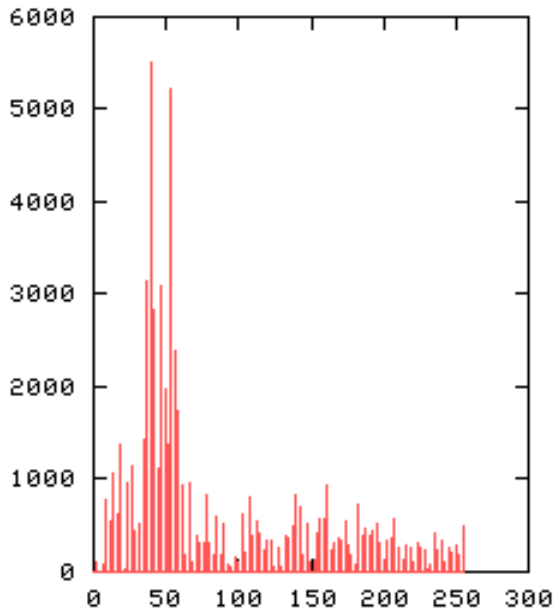




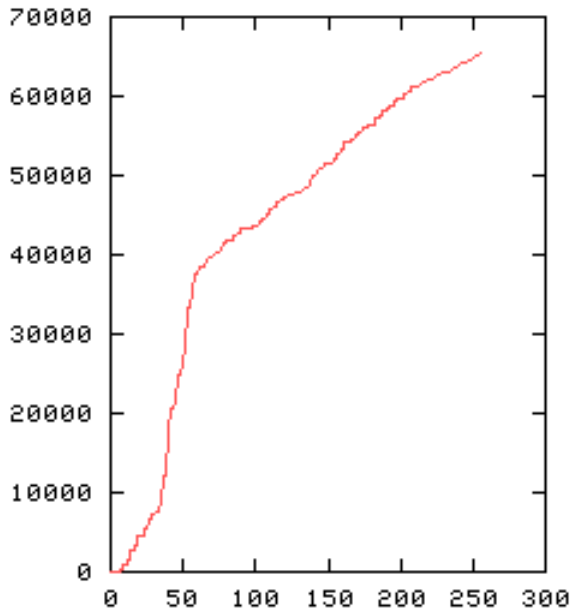
# Cumulative Histogram



Normal Histogram

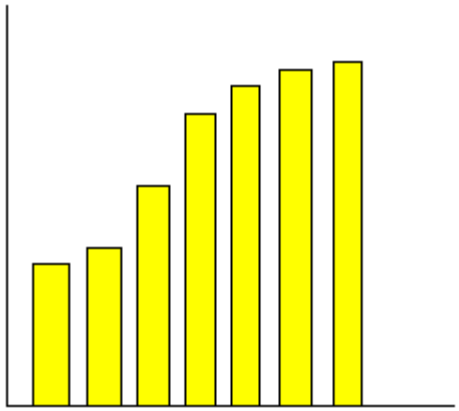



Cumulative Histogram

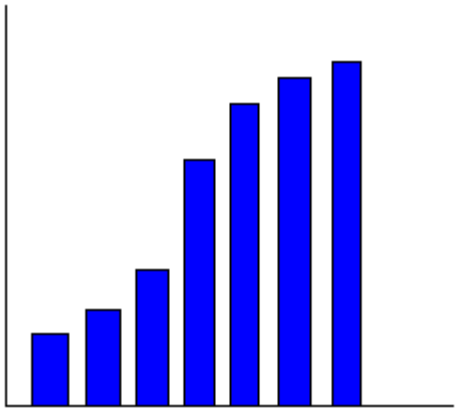


# Similarity Measures Using the Histograms

Histogram 1



Histogram 2



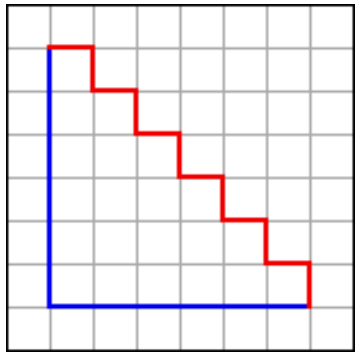
Need to quantify how similar two histograms are

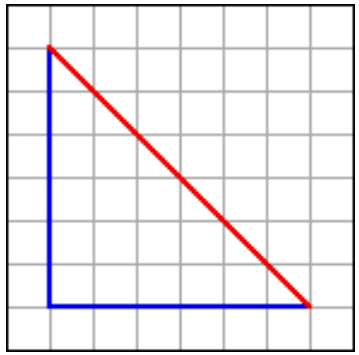
# Heuristic Histogram Distances

- Minkowski-form distance $L_p$

$$D(I,J) = \left( \sum_i |I_i - J_i|^p \right)^{1/p}$$

- Special cases:
  - $L_1$: absolute, cityblock, or Manhattan distance
  - $L_2$: Euclidian distance
  - $L_\infty$: Maximum value distance





# More heuristic distances

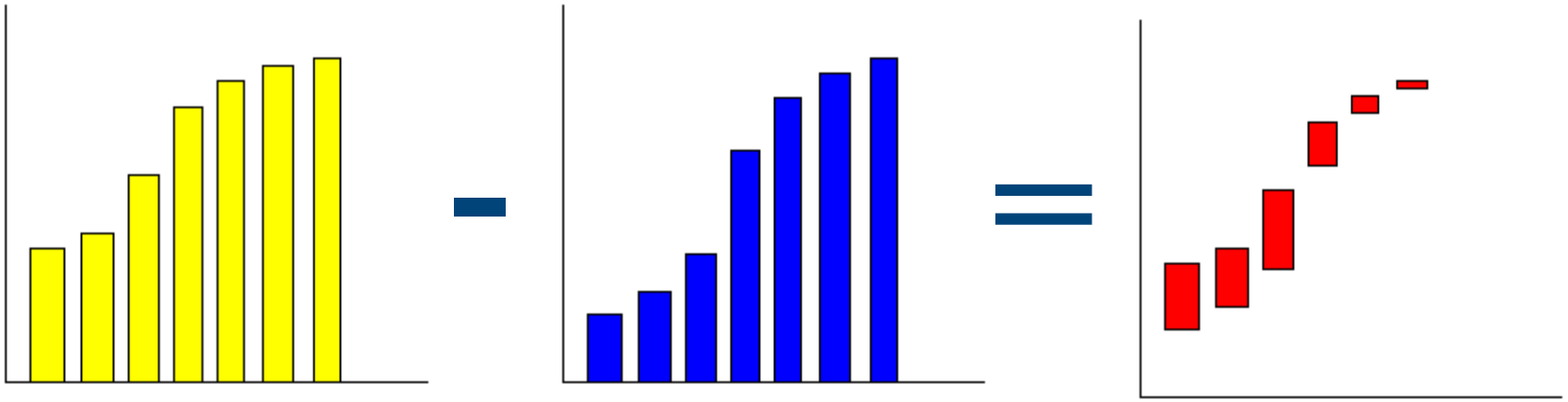
- Weighted-Mean-Variance (WMV)

$$D^r(I,J) = \frac{\left|\mu_r(I) - \mu_r(J)\right|}{\left|\sigma(\mu_r)\right|} + \frac{\left|\sigma_r(I) - \sigma_r(J)\right|}{\left|\sigma(\sigma_r)\right|}$$

  - Only includes minimal information about distribution

# Cumulative Difference Example

Histogram 1 Histogram 2 Difference



K-S =

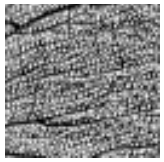
CvM =

# How would you test the perfomance of these algorithms?

- Three tasks
  - classification
  - retrieval
  - segmentation

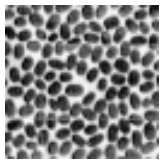
# Data Set: Color

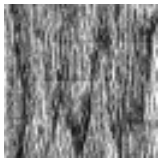
- Randomly chose 94 images from set of 2000
  - 94 images represent separate classes
- Randomly select disjoint set of pixels from the images
  - Set size of 4, 8, 16, 32, 64 pixels
  - 16 disjoint samples per set per image


# Data Set: Texture

- Brodatz album
  - Collection of wide range of texture (e.g. cork, lawn, straw, pebbles, sand, etc.)
- Each image is considered a class (as in color)
- Extract sets of 16 non-overlapping blocks
  - sizes 8x8, 16x16,…, 256x256

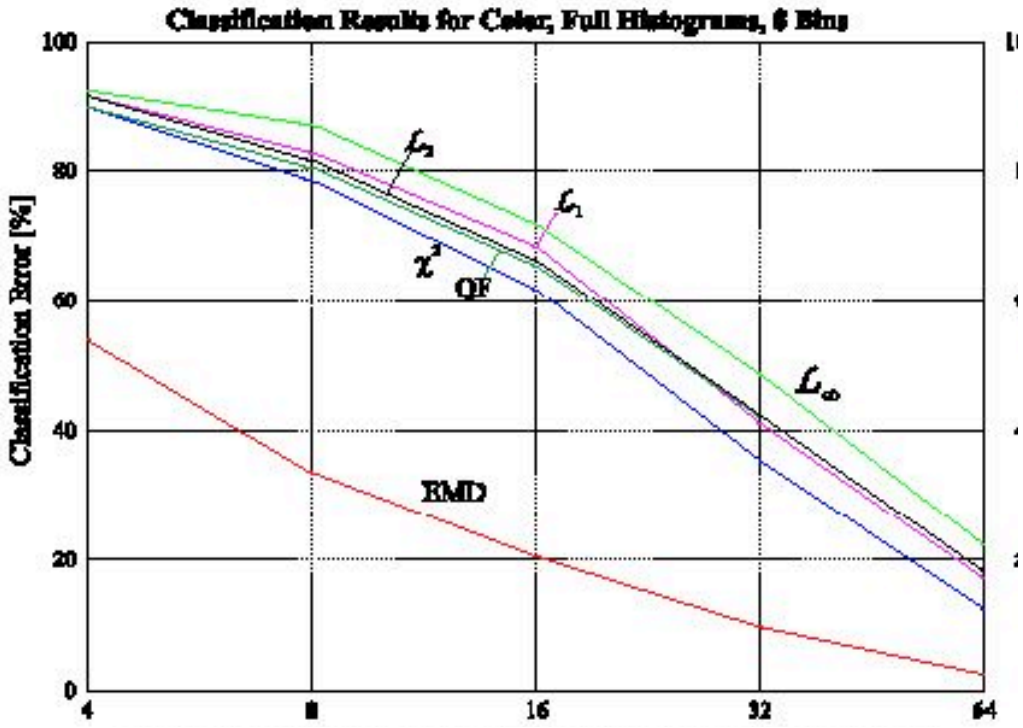



# Setup: Classification

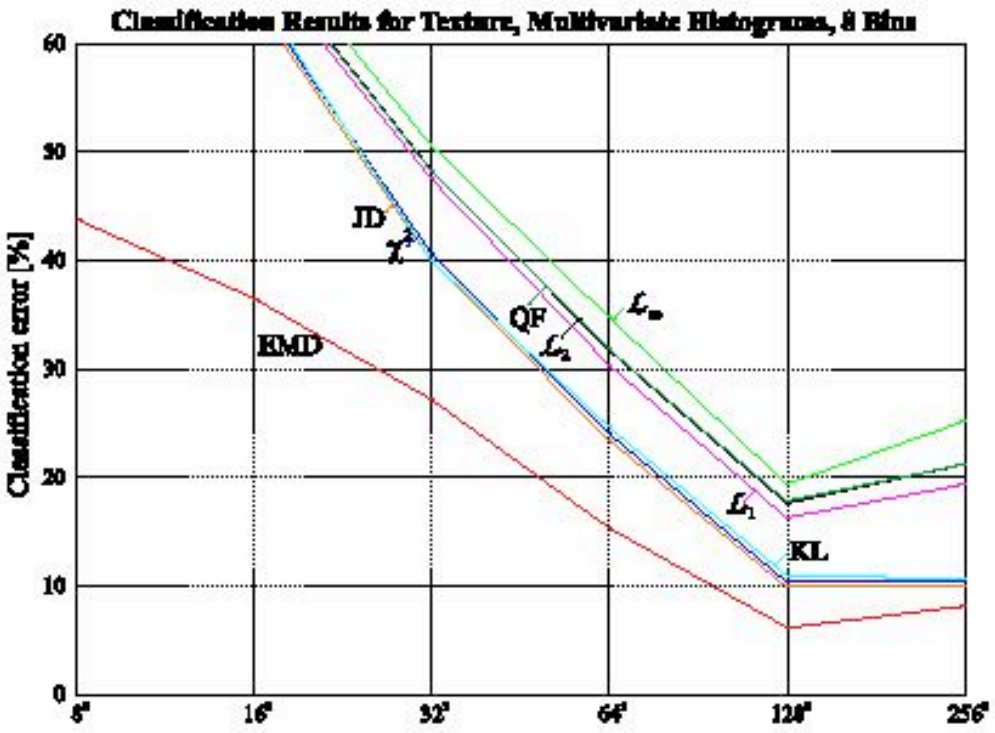
- How can we use similarity for classification?
- k-Nearest Neighbor classifier is used
  - Nearest Neighbor classification: given a collection of labeled points *S* and a query point **q**, what point belonging to S is closest to **q***?*
  - k nearest is a majority vote of the k closest points

# Results: Classification, color data set



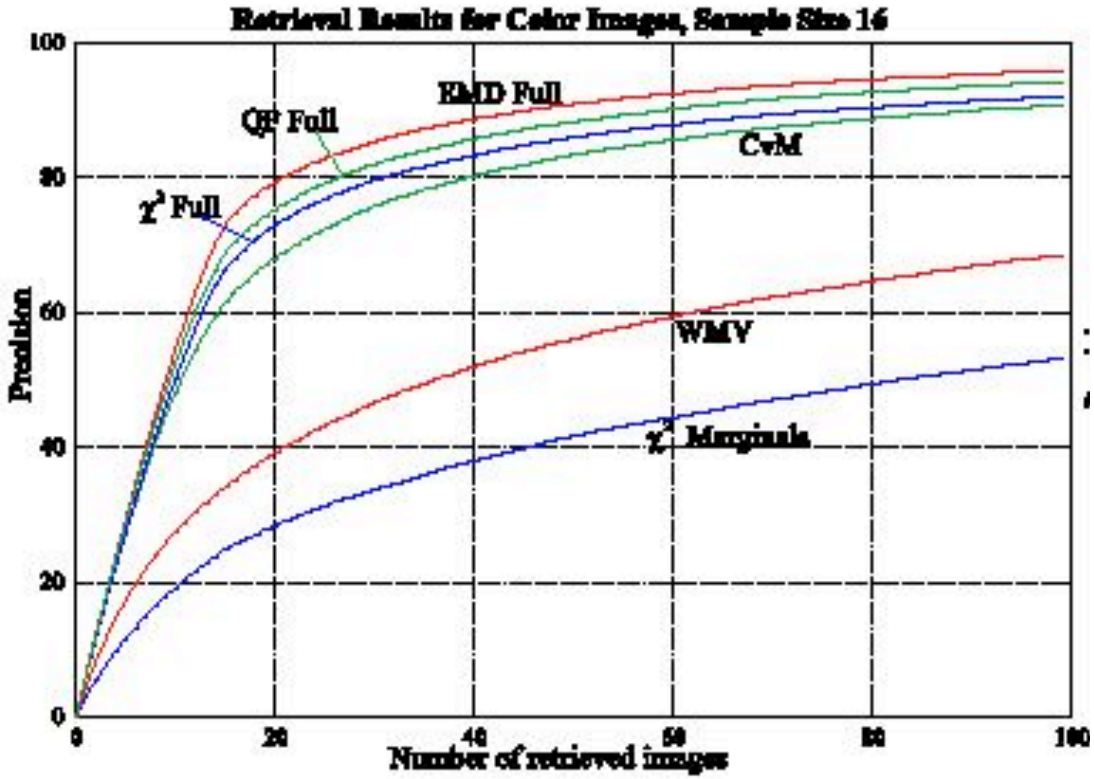

sample size

# Results: Classification, texture data set



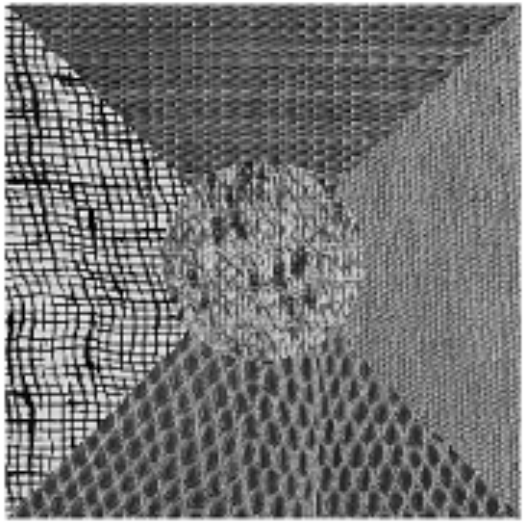

sample size

# Results: Image Retrieval



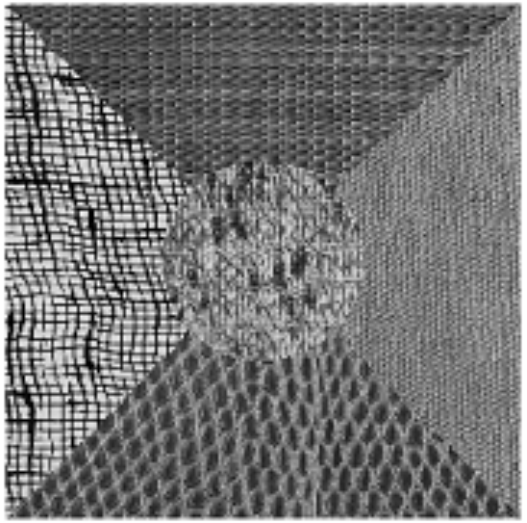
# Setup: Segmentation

- 100 images
- Each image consists of 5 different textures



# Setup: Segmentation

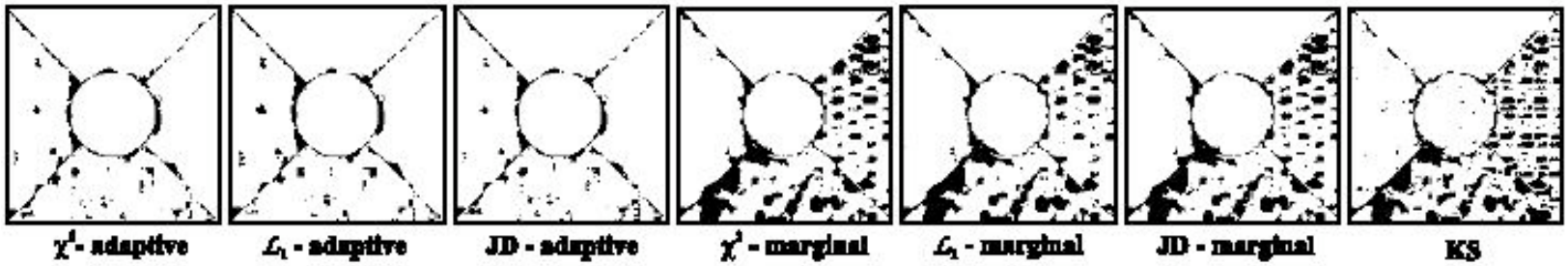
- How can we solve this problem using our similarity measures?



# Setup: Segmentation (cont.)

- Image is divided into 16384 sites (128 x 128 grid)
- A histogram is calculate for each site
- Each site histogram is then compared with 80 randomly selected sites
- Image sites with high average similarity are then grouped

# Results: Segmentation



# Something fun…

- http://www.popsci.com/gear-amp-gadgets/article/2009-09/building-virtual-cities-automatically-150000-flickr-photos

# Cyberchondria

# Homework for next time…

- Spend 15 minutes playing with three different image retrieval systems
  - http://en.wikipedia.org/wiki/Image_retrieval has a number
  - What works well?
  - What doesn't work well?
  - Anything interesting you noticed?
- You won't hand anything in, but we'll start class on Monday with a discussion of the systems