Content-Based Image Retrieval

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A sample of existing systems

- Google image search
- Google image labeler

Why not just use text?

- QBIC at the Hermitage Museum
- WebSEEk
- Simplicity
- WISE
- Riya
Possible applications

Basic technique

From http://www.amrita.edu/cde/downloads/ACBIR.ppt

Each image in database is represented by a feature vector: $(F_1, F_2, ... F^n)$

Query is represented in terms of same features: $Q$

Goal: Find stored image with vector $F_i$ most similar to query vector $Q$
• Typical distance measure: Inner product

\[ \mathbf{F}^i \cdot \mathbf{Q} = F_1^i Q_1 + F_2^i Q_2 + \cdots + F_m^i Q_m \]

Some issues

• Query format, easy of querying

• Speed

• Crawling, preprocessing

• Interactivity, user relevance feedback

• Visual features — which to use? How to combine?

• Curse of dimensionality

• Indexing

• Evaluation of performance
Types of Features

- Text
- Color
- Texture
- Shape
- Layout

Color representations

- Histograms (global and regional), correlograms

From: http://www.cse.ucsc.edu/classes/ee264/Winter02/xgfeng.ppt
• Moments of color distribution (mean, variance, skewness)

From: http://www2.cmp.uea.ac.uk/Research/compvis/ImageRetrieval/ImageRetrieval.htm

Texture representations

• entropy
• contrast
• Fourier and wavelet transforms
• Gabor filters
Feature Extraction [7] -- Texture

Grey-level co-occurrence matrix

http://www.amrita.edu/cde/downloads/ACBIR.ppt

http://www.mathworks.com/matlabcentral/files/9554/content/wavelets/tp2.html

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Shape representations

Need segmentation (another whole story!)

• area, eccentricity, major axis orientation

• Skeletons, shock graphs

• Fourier transformation of boundary

• histograms of edge orientations

From: http://www.lems.brown.edu/vision/researchAreas/ShockMatching/shock-ed-match-results1.gif
Issues in feature-vector matching

Dimension reduction (e.g., by Principle Components Analysis)

5 Principal Components
Feature selection (e.g., by *information gain* of feature)

Two different images might not have same number of features!

- cf. Pyramid matching (Grauman & Darrell, 2005)
Sets of features

\[ X = \{ \bar{x}_1, \ldots, \bar{x}_m \} \]

\[ Y = \{ \bar{y}_1, \ldots, \bar{y}_n \} \]

Pyramid match

\[ \max_{\pi: X \to Y} \sum_{x_i \in X} S(x_i, \pi(x_i)) \]
Multidimensional Indexing

- Compare with text indexing. Much higher dimensionality. Complex similarity measures

- Examples of indexing techniques:
  - k-d tree
  - r*-tree
Visual abilities largely missing from current CBIR systems

- object recognition
- perceptual organization
- similarity between semantic concepts

“The semantic gap”

“In general, current systems have not yet had significant impact on society due to an inability to bridge the semantic gap between computers and humans.”
How to bridge the semantic gap?