CS 414 – Multimedia Systems Design

Lecture 38 – Content-Based Image Search and Retrieval

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Spring 2009

Announcements

- Homework 2 due Wednesday, midnight, May 6th
- MP4 –pre-competition, April 30th , 216 SC
- MP4 competition, May 1, 5-7pm, 216 SC
- Final exam on Tuesday, May 12, 7-10pm, 1109 SC

Reading Assignment

- M. Flickner, H. Sawhney, W. Niblack, J. Ashley, Q. Huang, B. Dom, M. Gorkani, J. Hafner, D. Lee, D. Petkovic, D. Steele, and P. Yanker. “Query by image and video content: the QBIC system.” *IEEE Computer*, 28(9), September 1995. (Required)
- References for other recommended readings appear later in examples

Outline

- Motivation
- System components
  - Primarily based on IBM’s QBIC
- Examples
- Demo QBIC and Flickr

Motivation

- Text-based multimedia search and retrieval over metadata
  - File IDs
  - Keywords
  - Captions
  - Use existing methods for searching text

Motivation

- Content-based multimedia search and retrieval over actual data
  - Example images
  - Sketches and drawings
  - Selected color and texture patterns
  - Camera and object motion
  - Other graphical information
- Will show image search demos later

Example Applications

- Large scale multimedia search engines on the Web
  - Image search: Yahoo! , Google , Flickr
  - Video search: YouTube
- Media asset management systems in corporations
- Audio-visual broadcast servers
- Personal media servers for consumers
- Requirements: often depend on context and application scenarios

Example System Architecture

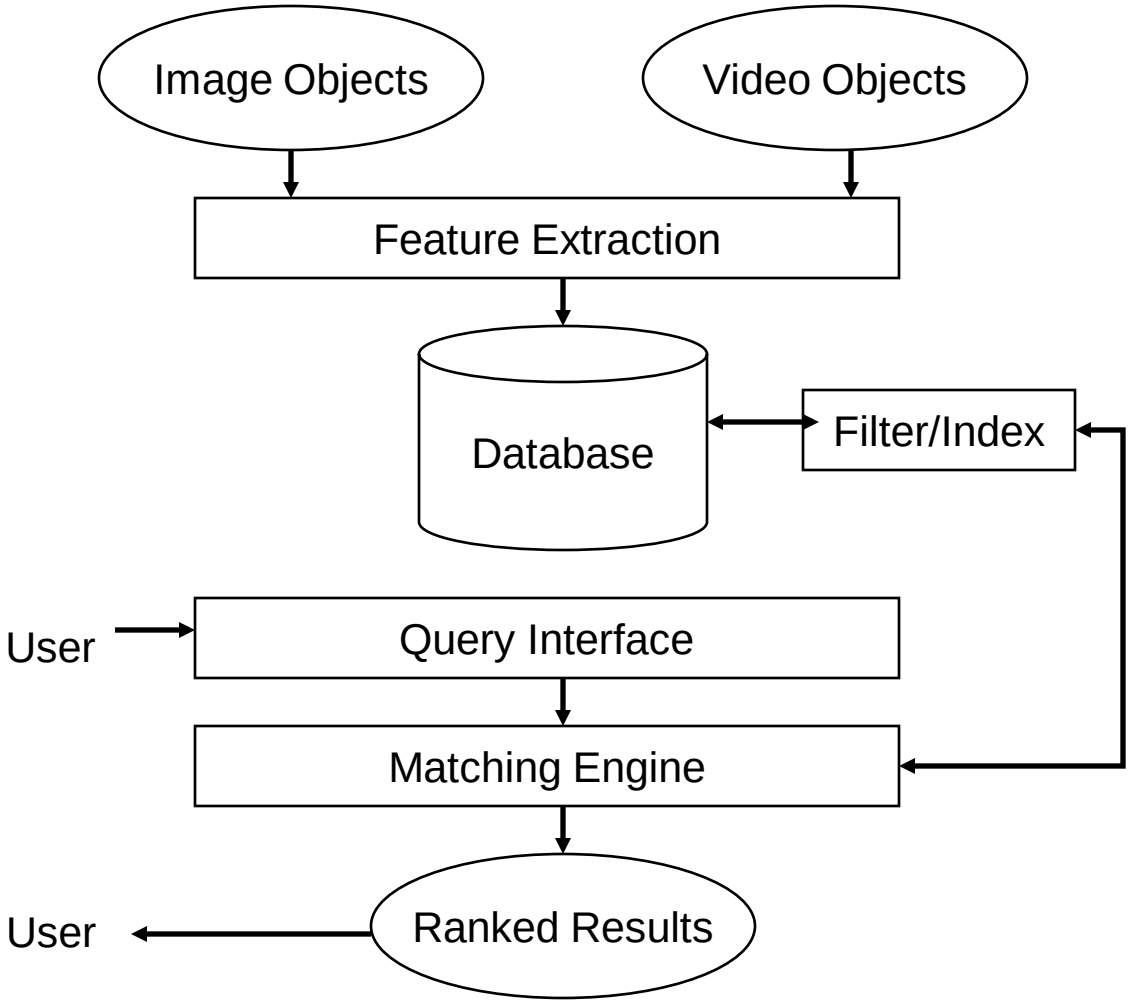
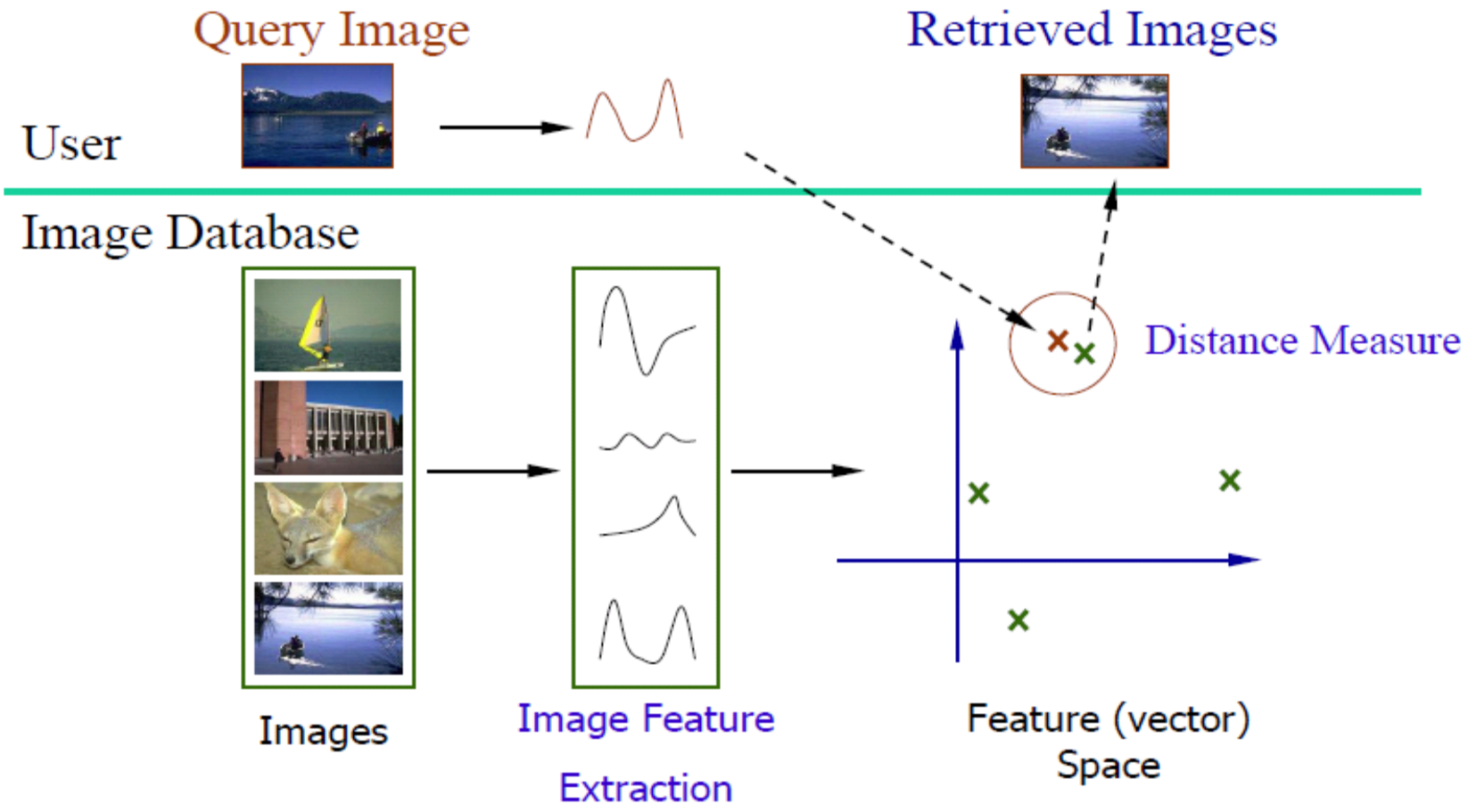


Image Retrieval

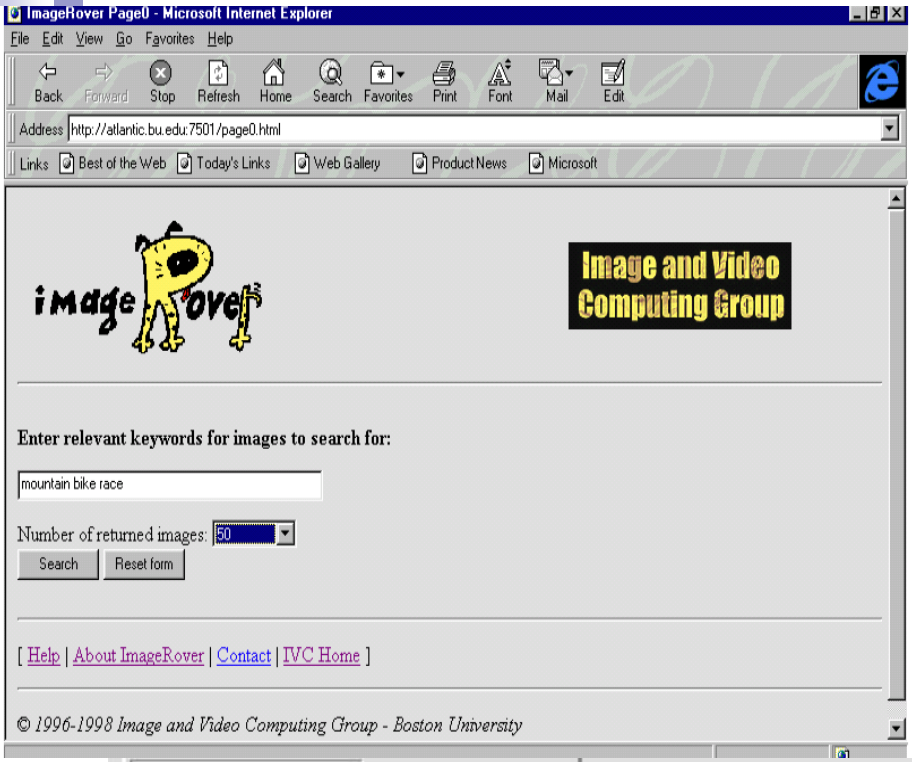


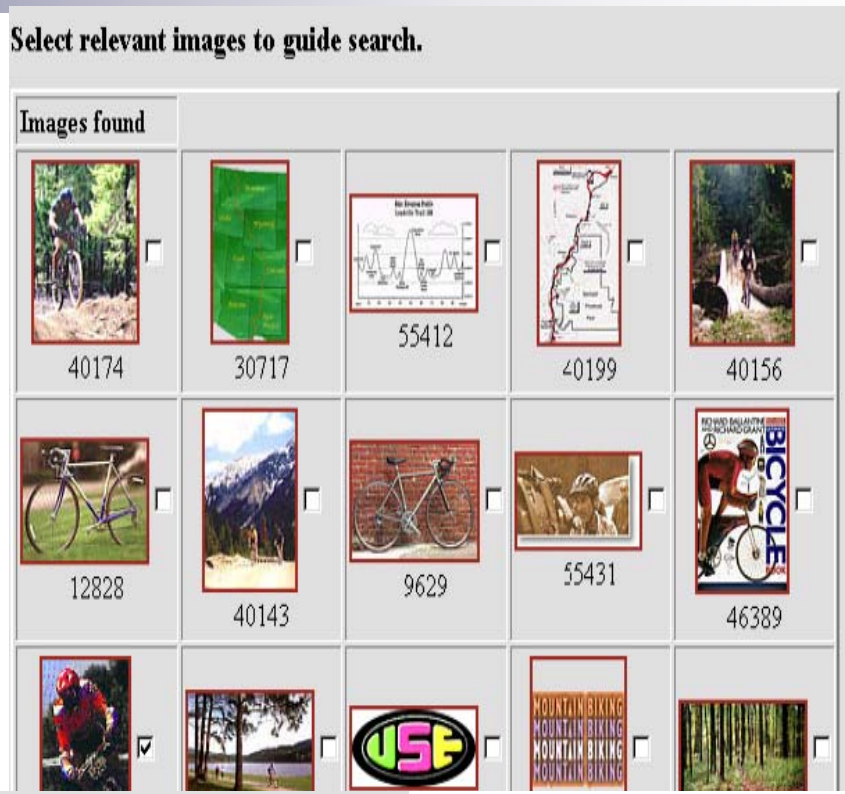
Stan Sclaroff, 2002 Presentation

Query Formulation

- QBE: Query by Example
  - Positive and negative example
- Text description
- Query by sketch
- Cluster-based retrieval
- Relevance feedback

Query by Text


ImageRover Page0 - Microsoft Internet Explorer
File Edit View Go Favorites Help
Back Forward Stop Refresh Home Search Favorites Print Font Mail Edit
Address http://atlantic.bu.edu:7501/page0.html
Links Best of the Web Today's Links Web Gallery Product News Microsoft
imageRover
Image and Video Computing Group
Enter relevant keywords for images to search for:
mountain bike race
Number of returned images: 60
Search Reset form
[Help | About ImageRover | Contact | IVC Home]
© 1996-1998 Image and Video Computing Group - Boston University


Select relevant images to guide search.
Images found
40174
30717
55412
40199
40156
12828
40143
9629
55431
46389

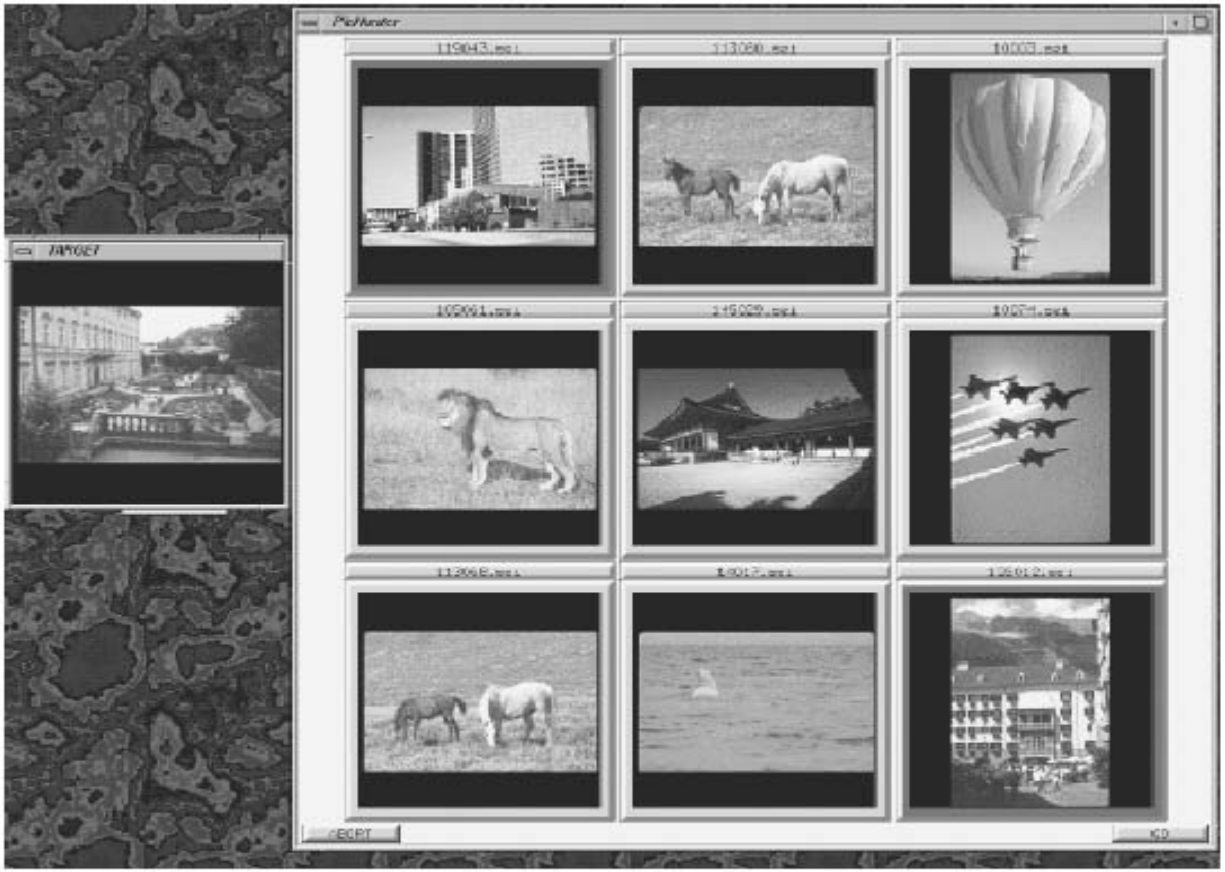

Images selected
58282
31445


Select relevant images to guide search.
Images found
31580
31406
31646
58343
31024

Query by Sketch

Example taken from Jacobs, Finkelstein, & Salesin
Fast Multi-Resolution Image Querying, SIGGRAPH 1995

Relevance Feedback



Example taken from Cox, Miller, Minka, Papathomas, and Yianilos, "The Bayesian Image Retrieval System, *PicHunter*: Theory, Implementation, and Psychophysical Experiments," *IEEE T-IP, 2000.*

Feature Extraction

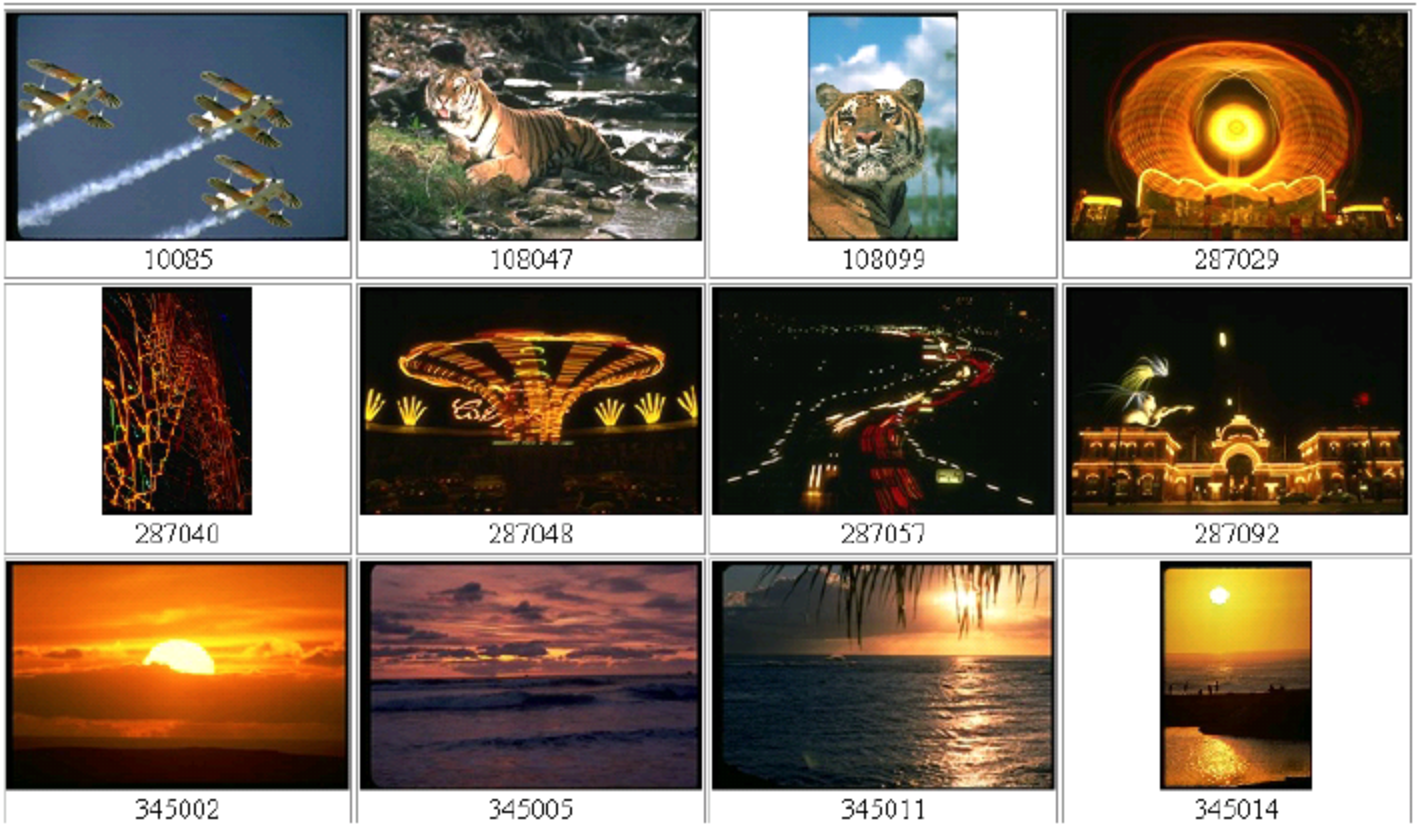
- Object identification
  - Manual, semi-automatic, or automatic
  - Contrast foreground and background
  - Represented internally with binary mask
- Color representation
- Texture representation
- Motion vectors (video only)

Color Histogram Extraction

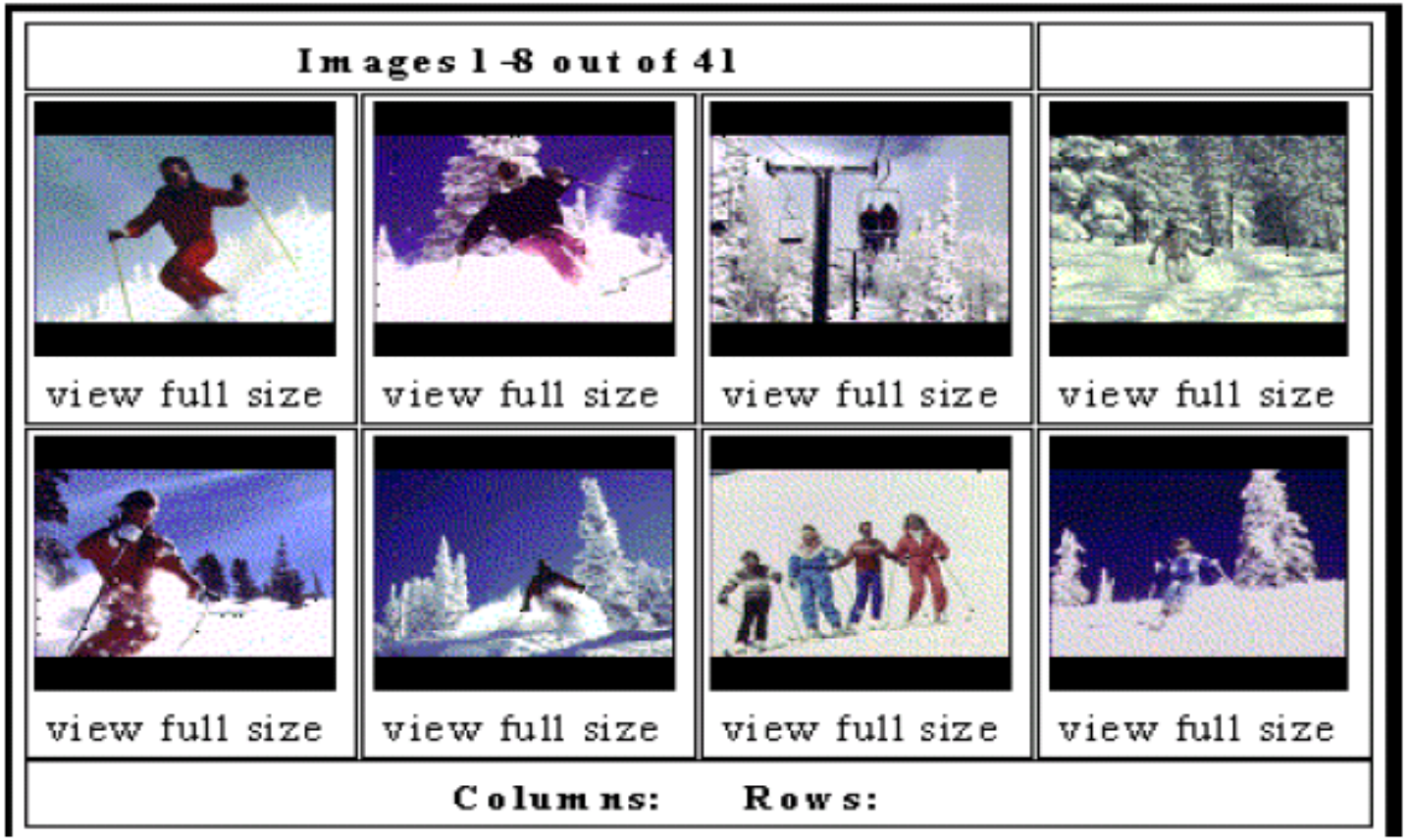
```
Off-line, for each image
    create histogram with a bin for each color
    initialize each bin counter = 0
        for each pixel in image:
            increment bin counter corresponding to pixel
            color
        end
```

On Line, use histograms in image similarity measure

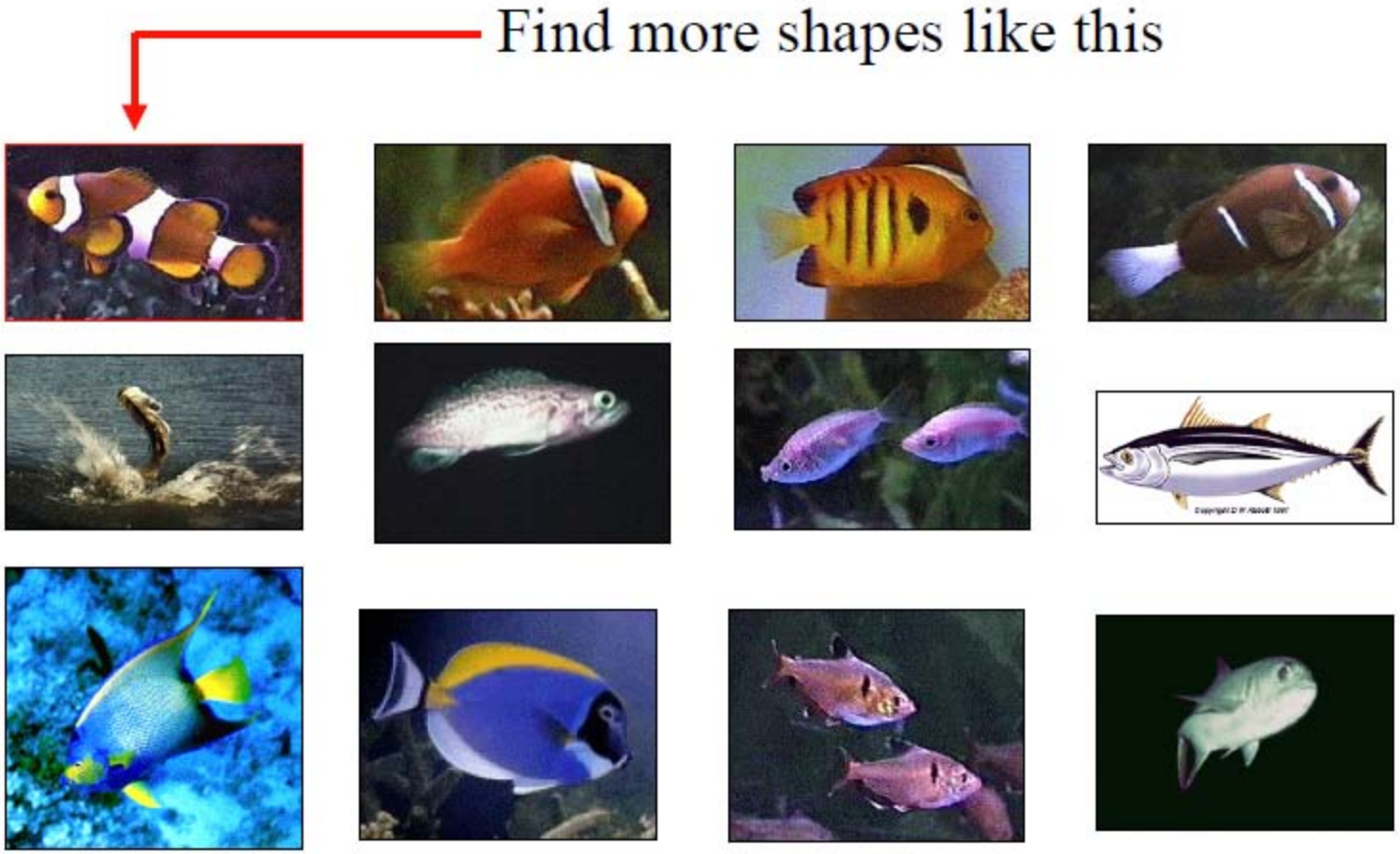
Images Classified as Sunsets using Overall Color Histograms



Retrieval by “color layout” in IBM’s QBIC



Shape-based retrieval of images



Filtering

- Multimedia retrieval can consist of two phases
  - First phase: computationally fast filter applied to all stored media objects (e.g., color histogram)
  - Second phase: perform complete matching operations on best matches from filter

Indexing

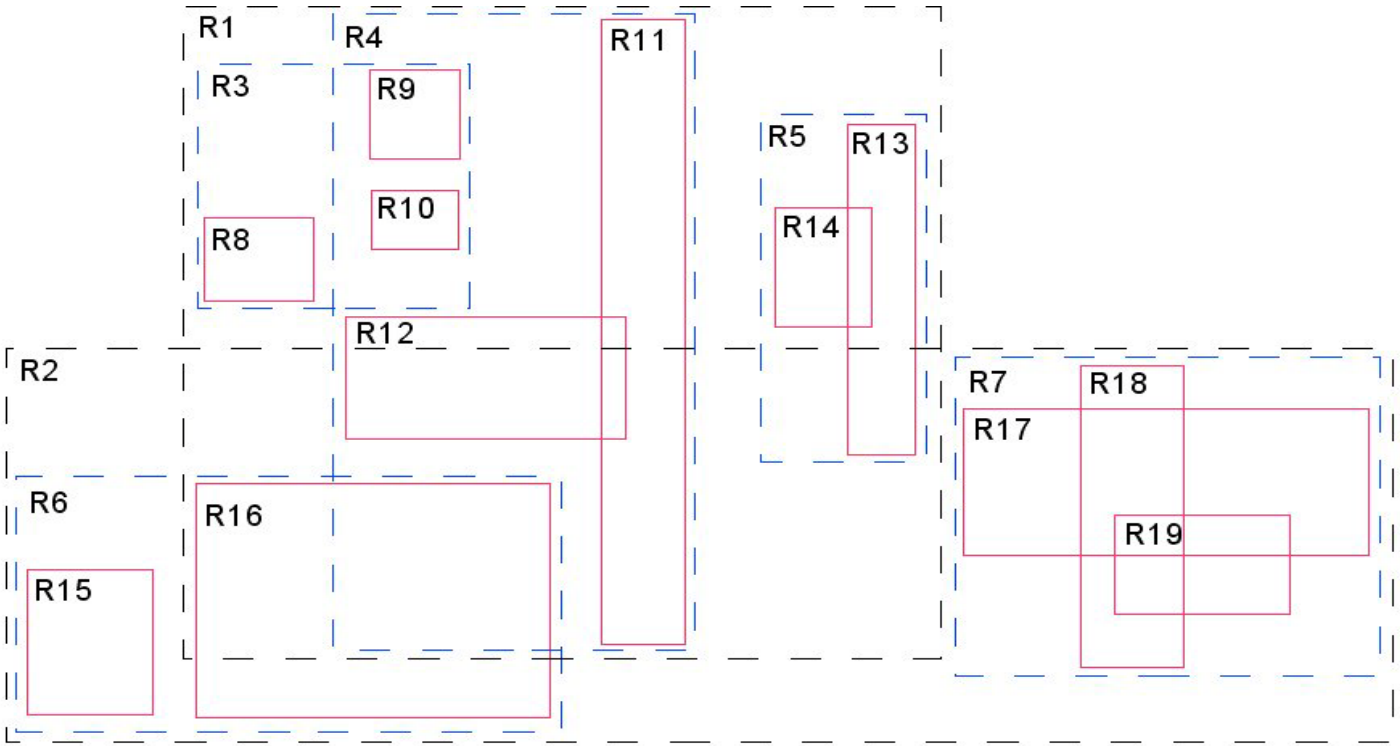
- Apply known data indexing techniques from database community
- Unlike traditional database contents, extracted multimedia features might be multidimensional
- Low dimensional spaces can be indexed using R*-trees

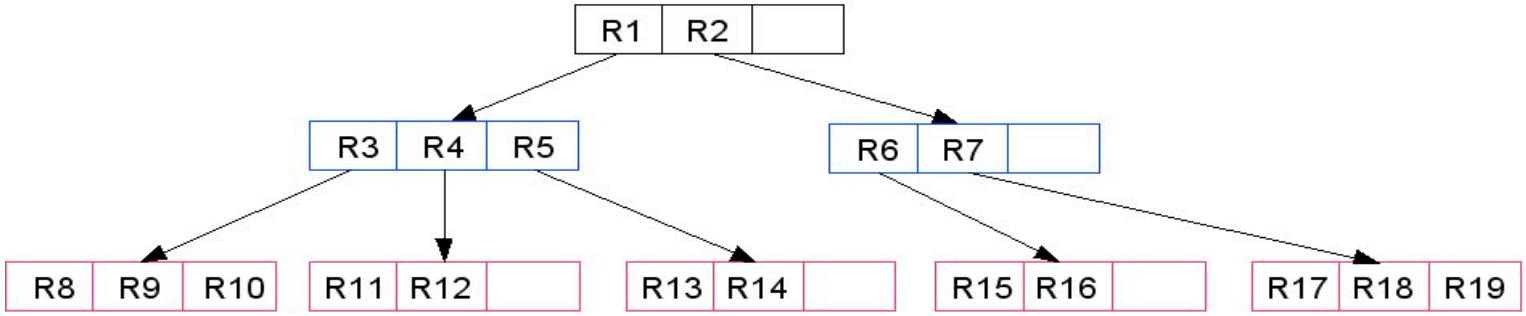
R-Trees

- Region tree is a multidimensional index
  - Like a B-tree for multiple dimensions
  - R*-tree is a variant that re-inserts entries upon overflow rather than splitting nodes
- Can be used to index low-dimensional features such as average color and texture
- High-dimensional features can be reduced to a lower number of dimensions

R-Trees

- Tree root is a bounding rectangle
- Child nodes are also bounding rectangles
  - Overlap is allowed at same tree level
  - All regions overlapping with query region must be searched
- Possible to have several levels and several dimensions


R1
R4
R3
R9
R11
R5
R13
R10
R14
R8
R12
R2
R7
R18
R17
R6
R16
R19
R15


R1
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R16
R17
R18
R19

Example: Photobook

- System from MIT
- Content-based image retrieval system
- Library of matching algorithms
  - e.g., Euclidean distance, histograms, wavelet tree distances
- Interactive learning agent to help determine user's intent

Example: Photobook

Source: Pentland, Picard, and Sclaroff. "Photobook: content-based manipulation of image databases." *International Journal of Computer Vision*, 18(3), 1996.

Example: MUSE

- System from Florida Atlantic University
- Supports user browsing
- Supports query-by-example
- Queries refined with user relevance feedback

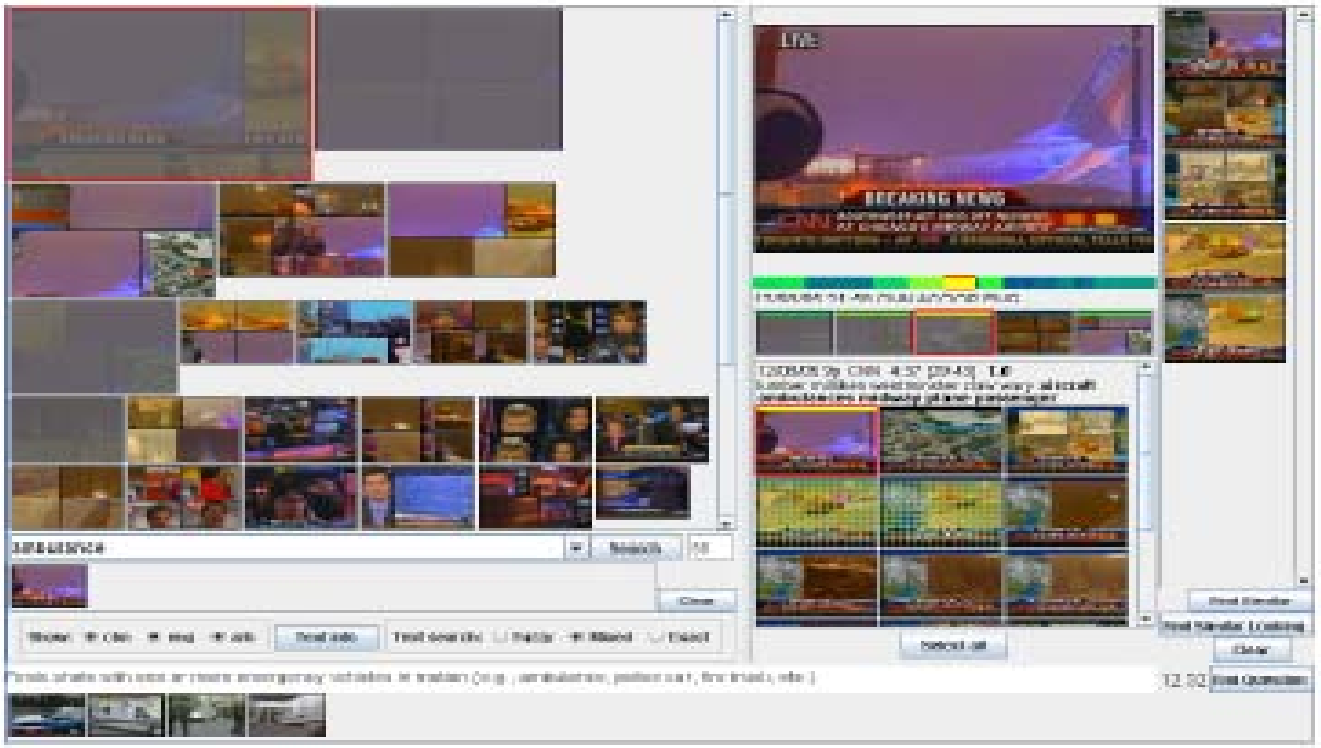
Example: MUSE

Source: Marques and Fuhrt. "MUSE: a content-based image search and retrieval system using relevance feedback." *Multimedia Tools and Application Journal*, 2002.

Example: MediaMagic

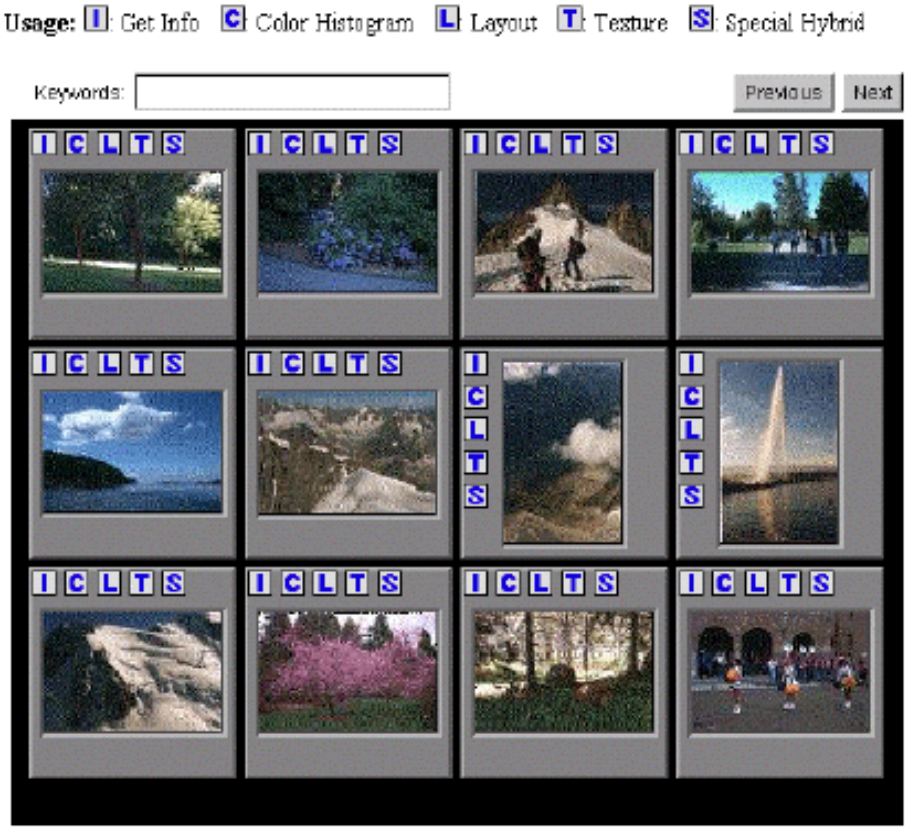
- System from FXPAL
- Supports multi-level index at three granularities
  - Program
  - Story
  - Shot
- Query interface
  - Initial query uses keywords
  - Subsequent queries may be “find similar” to previous query results

Example: MediaMagic



Source: Adcock, Cooper, and Chen. "FXPAL MediaMagic Video Search System." *CIVR*, 2007

QBIC: Query by Image Content



- First commercial system
- Search by:
  - color percentages
  - color layout
  - texture
  - shape/location
  - keywords

Try their demo: http://wwwqbic.almaden.ibm.com

Demo

- Russian museum's online digital collection uses QBIC engine
  - Supports color and layout search
  - The State Hermitage Museum
  - Flickr