Content-Based Image Retrieval (CBIR)

Xiaojun Qi

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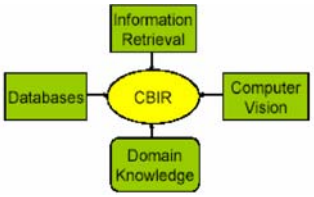
Content-Based Image Retrieval (CBIR) and Annotation System

- The driving forces
  - Internet
  - Storage devices
  - Computing power
- Two approaches
  - Text-based approach
  - Content-based approach



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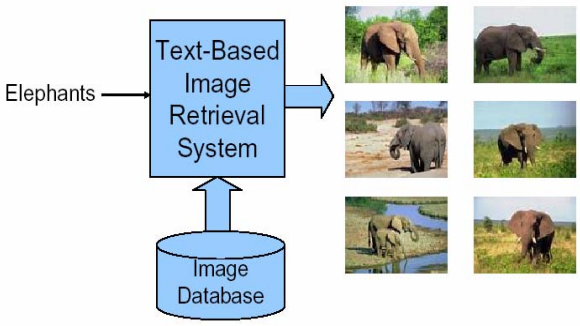
Text-Based Approach

- Input keywords descriptions



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Text-Based Approach: Index images using keywords

- Advantages: (Google, Lycos, etc.)
  - Easy to implement
  - Fast retrieval
  - Web image search (surrounding text)
- Disadvantages:
  - Manual annotation is not always available
  - Manual annotation is impossible for a large DB
  - Manual annotation is not accurate
  - A picture is worth a thousand words
  - Surrounding text may not describe the image

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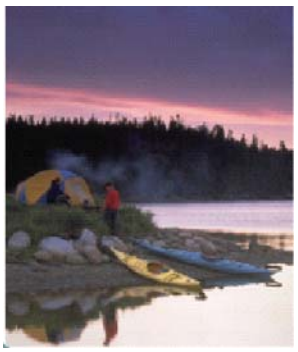
How to Describe This Image?



What is this image?

- Sunset scene
- River or lake
- Camping site
- People
- Kayak
- Picnic
- National Park

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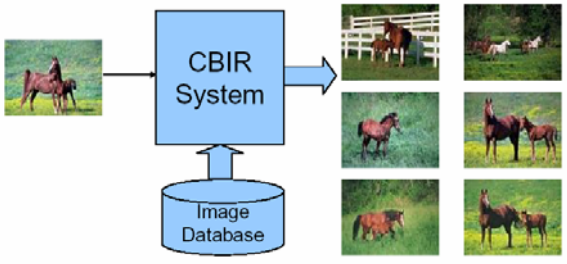
Content-Based Approach

Index images using low-level features



Content-based image retrieval (CBIR): search pictures as pictures

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Content-Based Approach: Index images using images

- Advantages
  - Visual features, such as color, texture, and shape information, of images are extracted automatically
  - Similarities of images are based on the distances between features

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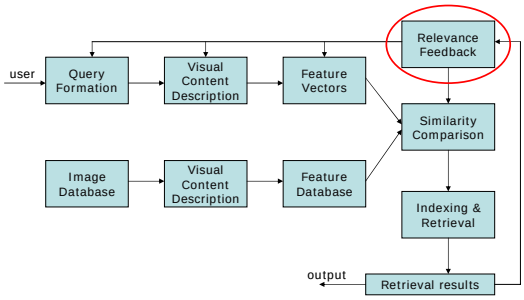
A High-Level Diagram for CBIR



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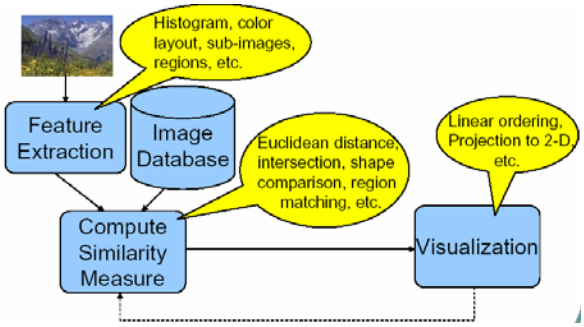
A Data Flow Diagram



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Feature Extraction

- Global features: They can avoid the problems of inaccurate image segmentation
  - Global color histogram
  - Global edge histogram
- Regional features: Segmentation needs to be performed to obtain each potential region.
  - Edge flow based segmentation
  - Color based segmentation

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Sample Segmentation Results

Original Image | 2 Regions | 3 Regions | 4 Regions

5 Regions | 6 Regions | 7 Regions

Original Image | 2 Regions | 3 Regions | 4 Regions

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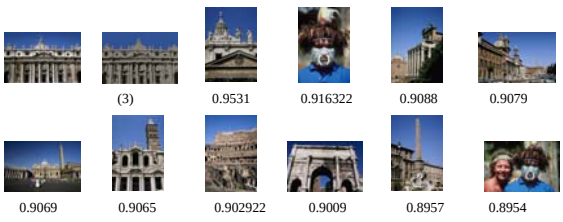
Sample Segmentation-Based Retrieval Results



9 matches out of 11, 14 matches out of 20

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CBIR Applications

- Commerce (fashion, catalogue, … …)
- Biomedicine (X-ray, CT, ……)
- Crime prevention (security filtering, … …)
- Cultural (art galleries, museums, … …)
- Military (radar, aerial, … …)
- Entertainment (personal album, … …)

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Previous Work on CBIR

- Starting from early 1990s
- General-purpose image search engines
  - IBM QBIC system
  - MIT Photobook System
  - VIRAGE system
  - Columbia VisualSEEK and WebSEEK Systems
  - UCSB NeTra System
  - UIUC MARS System
  - Stanford SIMPLIcity System
  - NEC PicHunter System
  - Berkeley Blobworld System

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Open Problems

- Nature of digital images: arrays of numbers
- Descriptions of images: high-level concepts.
  - Sunset, mountain, dogs, … …
- Semantic gap
  - Discrepancy between low-level features and high-level concepts
  - High feature similarity may not always correspond to semantic similarity
  - Different users at different time may give different interpretations for the same image.

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Image Semantics

- Image semantics may be related to objects in the image
- Semantically similar images may contain semantically similar objects
- Can a computer program learn semantic concepts about images based on objects?

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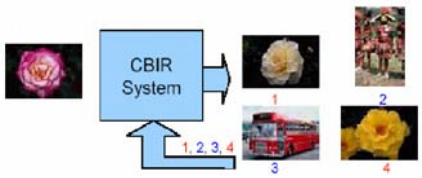
Narrowing the Semantic Gap

Relevance Feedback



- Adjusting similarity measure [Rui et al. IEEE CSVT 8(5); Cox et al. IEEE Trans. IP 9(1)]
- Support vector machine [Tong et al. ACM MM'01]

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CBIR Project Emphasis: Relevance Feedback Based CBIR

Step 1: Use common low-level feature vector to retrieve images. Some example features are:

- Color histogram
- Color moments
- Color coherence vector
- Tamura coarseness histogram
- Pyramid wavelet texture feature

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Relevance Feedback Based CBIR (Cont.)

Step 2: The user provides the positive and negative feedback examples, which are incorporated to refine query process.

Step 3: Retrieve a new set of images based on the refined query.

Step 4: Repeat Step 2 and Step 3 until the user is satisfied with the retrieval results.

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Sample Refinement Strategies

Strategy 1: Use the features of the positive examples to update the parameters of the corresponding semantic Gaussian class. Apply penalty function to an image similar to a negative example.

Strategy 2: Use the features of the positive and negative examples to emphasize relevant features and de-emphasize the nonrelevant features.

Strategy 3: Use the positive and negative examples to refine the decision boundary to classify two kinds of semantic images.

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Accomplishments in Previous REU

- Published 3 premier conference papers
  - *Int. Conf. on Multimedia and Expo*, July 2-5, Beijing, China, 2007.
  - *International Conference on Acoustics, Speech, and Signal Processing*, May, Hawaii, 2007.
  - *International Conference on Acoustics, Speech, and Signal Processing,* May, Toulouse, France, 2006.
- Sent 2 students to attend the conference
- Hope to get at least 1 conference paper from this REU program

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