



IMAGE RETRIEVAL: PAST, PRESENT, AND FUTURE

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Outline

- Background & Motivation
- Content-Base Image Retrieval (CBIR)
 - Visual Feature Extraction
 - Multi-Dimensional Indexing
 - Retrieval System Design
- Future Research Directions
- Conclusions



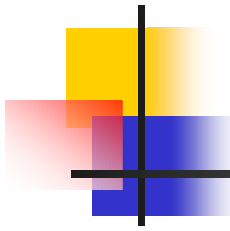
Background & Motivation

- Two research directions
 - Text-based image retrieval (70's)
 - Huge amount of labor on annotation
 - Rich content and subjectivity
 - Content-based image retrieval (90's)
 - Based on color, texture, shapes.
 - Mainly contributed by Computer Vision community



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Content-Based Image Retrieval (CBIR)

- Three fundamental bases
 - Visual Feature Extraction
 - Multi-Dimensional Indexing
 - Retrieval System Design



Visual Feature Extraction

- Visual Features including:
 - Color
 - Texture
 - Shape
 - Color Layout
- Segmentation



Color

- Color Histogram
 - Histogram intersection (*Swain & Ballard*)
 - Cumulated color histogram (*Stricker & Orengo*)
- Color Moments (*Stricker & Orengo*)
 - Overcome the quantization effects
- Color Sets (*Smith & Chang*)
 - Facilitate search over large-scale image collection



Texture

- Texture Representations
 - co-occurrence matrix (*Haralick et al.*, early 70's)
 - Statistically explored the gray level spatial dependence of texture
 - computational approximation (Tamura et al.)
 - Visually meaningful than co-occurrence matrix (e.g. entropy)
 - wavelet transform (early 90's)
 - Orthogonal/bi-orthogonal
 - Tree-structured transform
 - Gabor transform (best by *Ma and Manjunath*)



Shape

- Boundary-based shape representation
 - Fourier Descriptor (*Zahn et al.*)
 - Turning Function (*Arkin et al.*)
 - Wavelet Descriptor (*Chuang & Kuo*)
- Region-based shape representation
 - Moment Invariants (*Hu*)
- 3D shape representation
 - Normalizing Fourier Descriptor (*Wallace & Wintz*)
 - Algebraic Moment Invariants (*Taubin*)



Color Layout

- Sub-block division
 - Cannot get accurate local color.
 - Computation and storage expensive.
- Segment into color regions
 - Accurate but reliable segmentation is difficult
- Color tuple histogram (*Rickman & Stonham*)
- Overlapping fuzzy region (*Stricker & Dimai*)
- Classification of each pixel (*Pass et al*)
- Color correlogram (*Huang et al.*)



Segmentation

- Automatic segmentation
 - Morphological operation, i.e., opening & closing (Lybanon et al.)
 - Watershed (Hansen & Higgins)
 - Fuzzy entropy (Li et al.)
- Human assistance
 - Computer-assisted boundary extraction (Samadani & Han)
 - Active contours (Daneels et al.)
 - Clustering & grouping (Rui et al.)



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High Dimensional Indexing

- High dimensionality
 - Feature vectors space is of order 10^2
- Non-Euclidean similarity measure
 - Histogram Intersection
 - Cosine
 - Correlation



Dimension Reduction

- Karhunen-Loeve Transform (KLT)
 - Eigenimage PCA (Ng & Sedighian)
 - Low-rank SVD (Chandrasekaran)
- Column-wise Clustering (Salton et al.)
- Post-verification
 - Discriminant analysis (Fisher)



Multi-dimensional Indexing

- Tree Indexing
 - Cell method, quad-tree & k-d tree
 - R-tree (Guttman) & its variants, e.g. R^+ tree (Sellis et al.), R^* tree (Beckman & Kriegel)
- Non-Euclidean similarity measure
 - Incremental clustering (Charikar et al.)
 - Self-Organization Map (SOM) Neural Nets (Zhang & Zhong)



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A Typical System Architecture

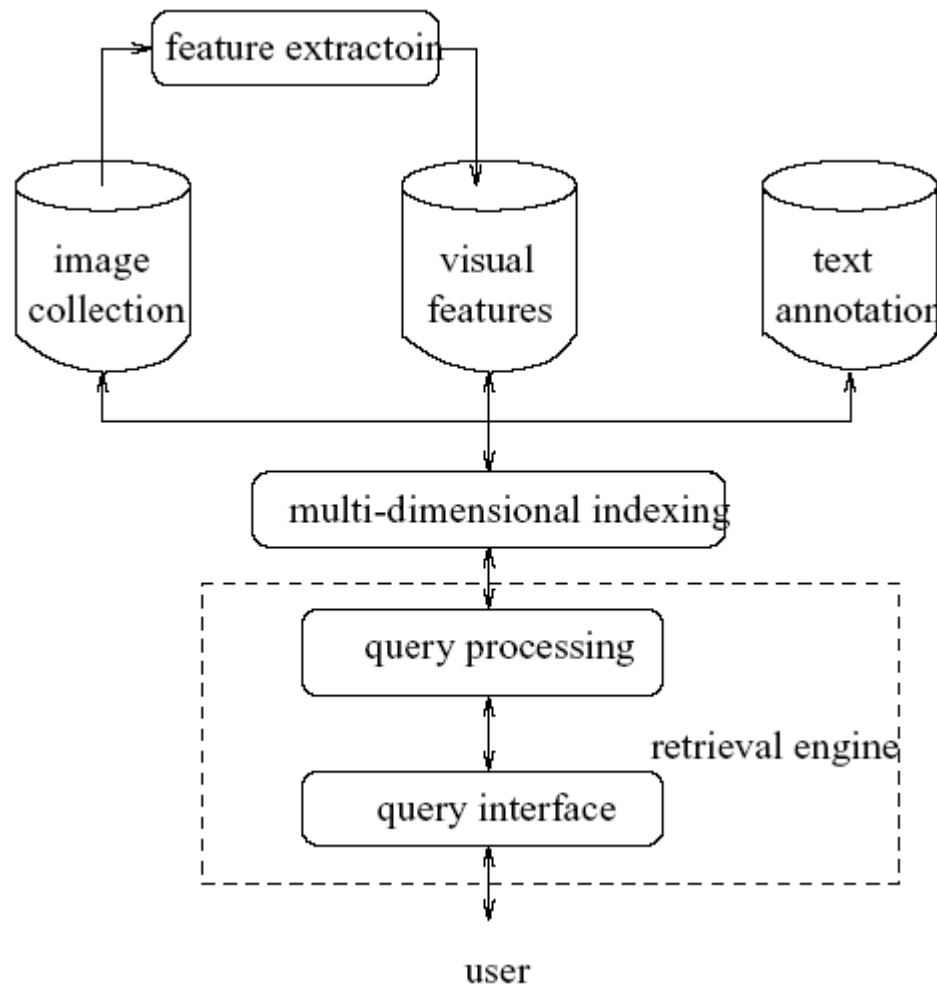




Image Retrieval Systems

- QBIC (Query by Image Content)
- Virage
- RetrievalWare
- PhotoBook (MIT)
- VisualSEEK & WebSEEK (Columbia)
- Netra (UCSB)
- MARS (UIUC)



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Future Research Directions

- Human in the loop
- High-level concepts and low-level features
- Web oriented
- High dimensional indexing
- Performance evaluation criterion and standard test-bed
- Human perception of image content
- Integration of disciplines and media



Conclusion

- Technical reviews
 - Visual feature extraction
 - Multi-dimensional indexing
 - System design
- Two major characteristics
 - Multi- and inter-discipline
 - Interactivity nature between human and computer