ECE624

Week 3-b

Performance Parameters for an Image Retrieval System

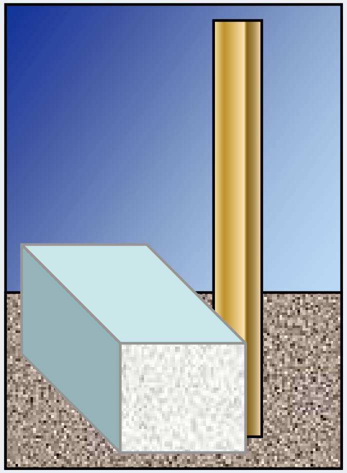
Recall: Ratio of relevant items retrieved to the total number of items in the database. It measures the ability of a system to present all relevant items

Precision: Ratio of relevant items retrieved to the total number of items retrieved. It measures the ability to present only relevant items.

Note: Number of false positive = 1 - Precision

Indexing Problem

- Feature extraction
- Data structures for fast retrieval



Challenges in Image Indexing

- Application dependencies
- Similarity measures
- Scalability issues

Existing Solutions

- Raw image domain methods
  - QBIC
  - VisualSEEK
- Transform domain methods (Wavelets only)
  - *Fast Multiresolution Image Querying*
  - *Wavelet-based Image Indexing and Searching(WBIIS).*

QBIC (IBM)

- Features:
  - Color histogram
  - Texture
  - Shape
  - Bit map
  - Edge map

- Problems:
  - Linear search for all images in the DB is expensive
  - Feature vector computation is costly

VisualSEEK (Columbia University)

- Features:
  - Color histogram
  - Objects and regions in the image
  - Inter-region relationships

- Search based on
  - Single/multiple region matching
  - Complex feature vector matching

Fast Multiresolution Image Querying

- Haar wavelets, color space (YIQ)
- 128x128 image size
- Feature vector uses 40-60 most significant coefficients from each color space
- Linear search in DB
- Query time depends on DB size

Wavelet-based Image Indexing and Searching(WBIIS) (Stanford University)

- Daubechies Wavelet transform
- Feature Vector:
  - Standard deviation of upper left 8x8 block of coefficients for each color
  - 8x8x3 coefficient matrix
  - 16x16x3 dimensional final feature set

Wavelet-based Image Indexing and Searching (WBIIS) (Stanford Univ, cont.)

- Performance results of search on 10,000 images
  - Standard deviations to obtain best 2000
  - Euclidean distance comparison of 8x8x3 matrix
  - Final selection using 16x16x3 matrix
  - 3.3 secs to select best 100 matches
- Problems: Not scalable

Liang, Kuo (University of Southern California)

- Features
  - Frequency of important coefficients in each sub-band
  - Luminance histogram
  - Binary quantization of lowest subband
  - Color histogram
- Independent or joint use of features for retrieval

Wavelet Domain Methods

System	Image Size	Database Size	Feature Vector Size	Search Time
Liang Kuo	192x128	2119	212 bytes	NA
WBIIS	128x128	10,000	~1000 bytes	3.3secs
QBIC	100x100	1000	NA	2-40secs
U. Washington	128x128	1093	>150 bytes	47.46 secs

Issues

- Scalability issues
- Image keys are long (typically 256 bytes)
- Ratio of number of images retrieved to the number of images selected is high
- Feature extraction and indexing are treated as two separate problems in general in a non-uniform manner

Wavelet-Based Approach

- Features based on the properties of the wavelet coefficients
- Utilization of multiresolution property of the wavelet transform
- Classification of images to reduce the search space
- Efficient data structures for fast image indexing and retrieval

Image Databases: Summary

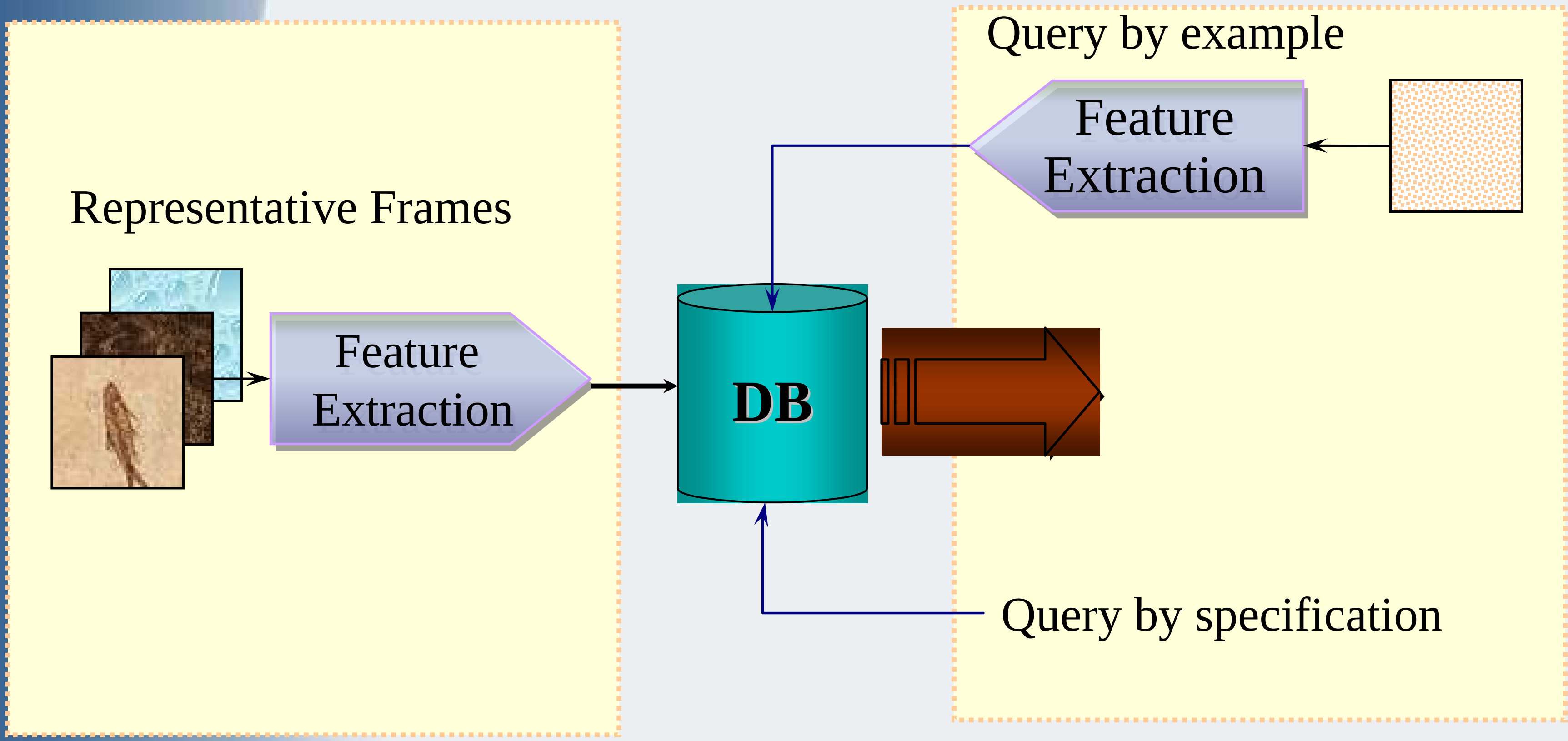
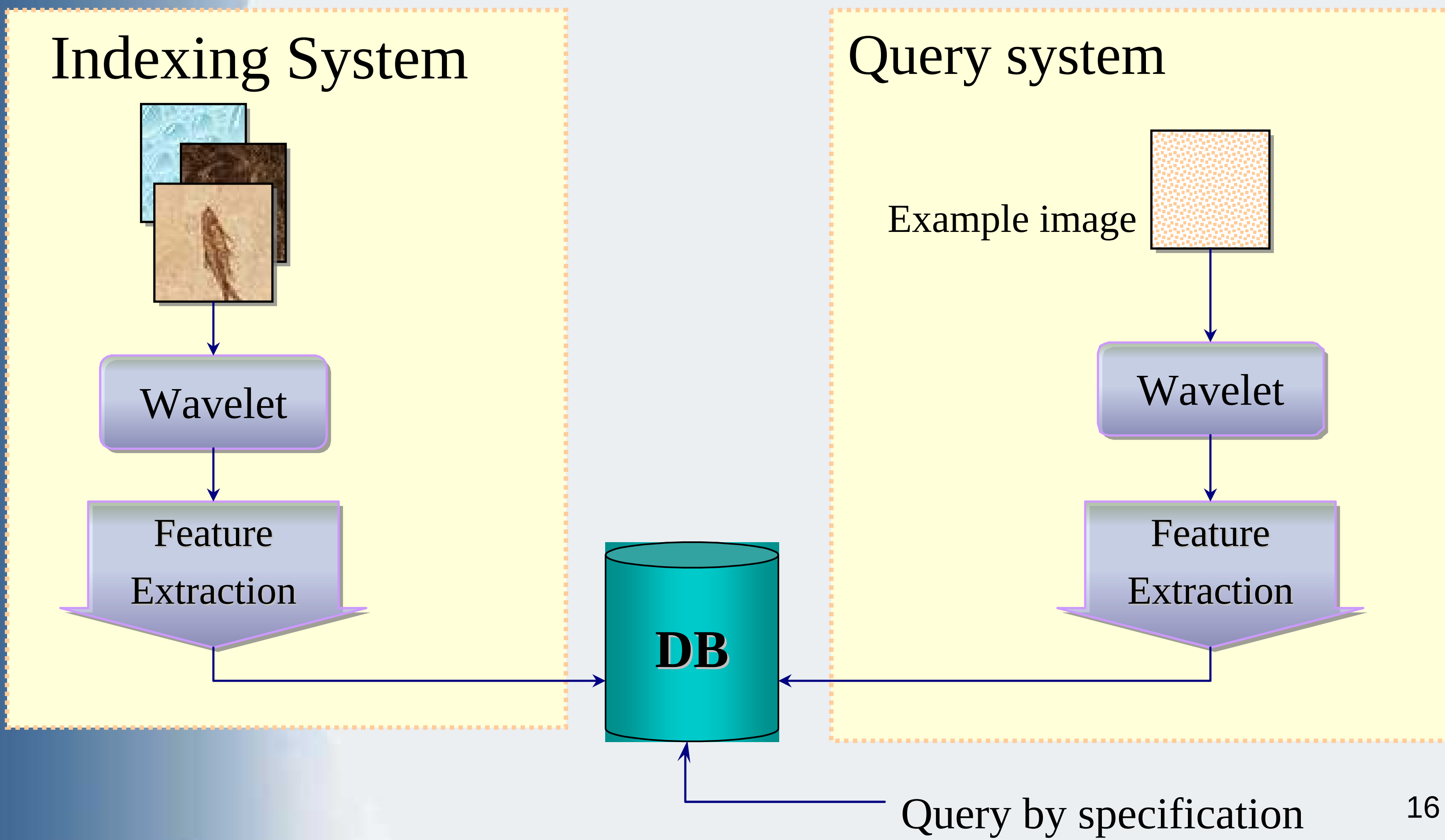


Image Database System: Summary

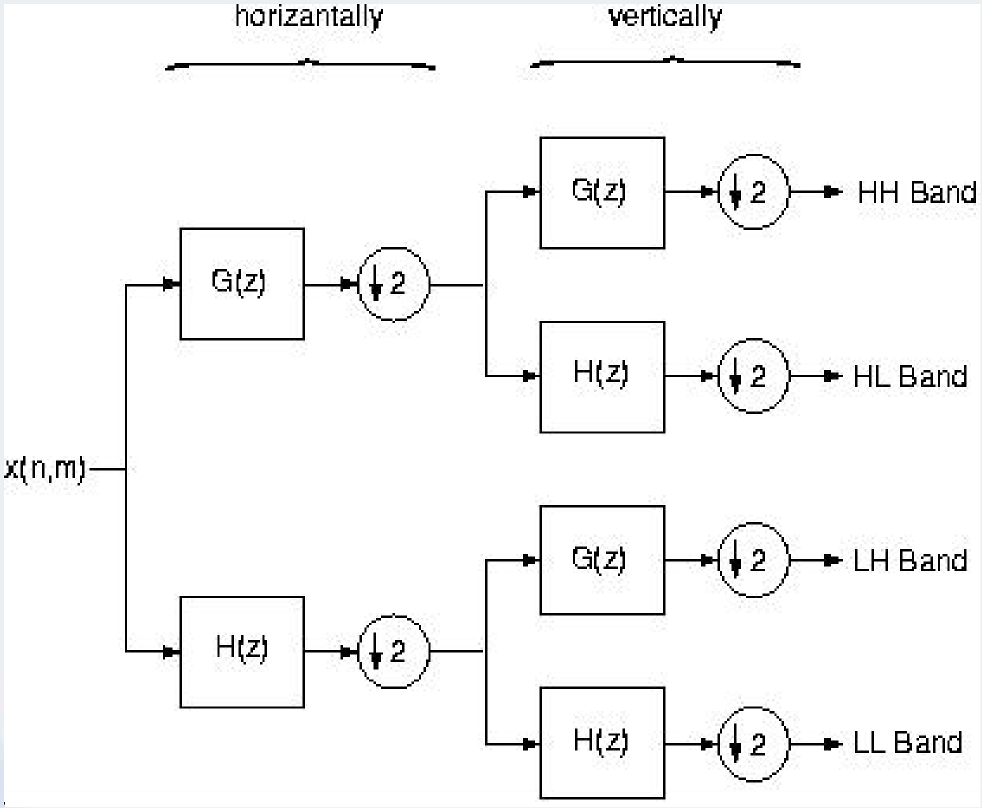


Why Wavelet Transform?

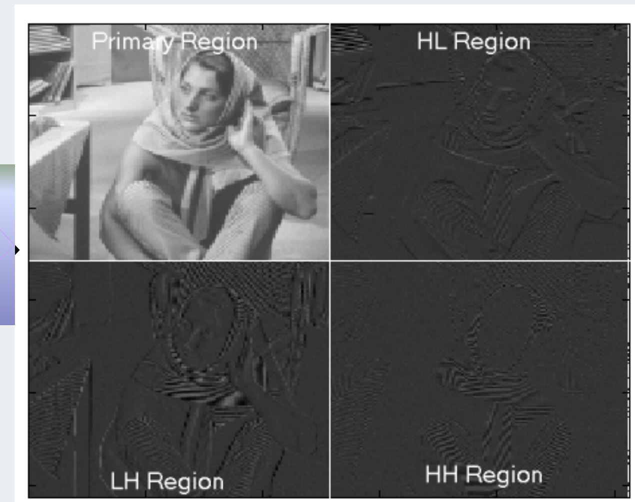
- Real-life data, such as audio and images, is not totally random but tends to have certain level of correlation.
- Correlation is local

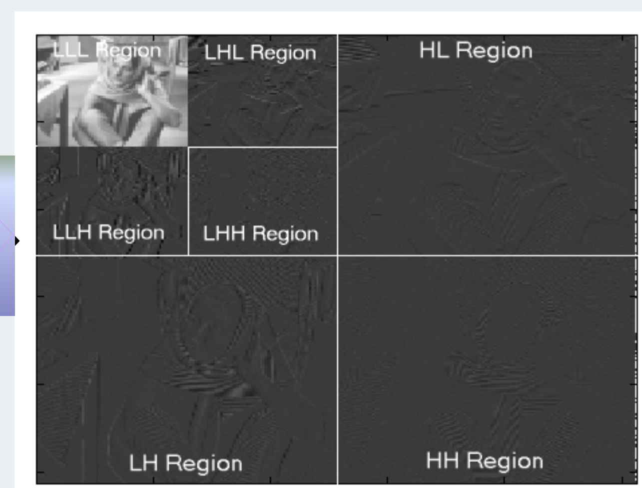
- Better space-frequency localization
- Signal/image analysis at multiple resolutions
- Low computational complexity

2D Wavelet Transform (Mallat)

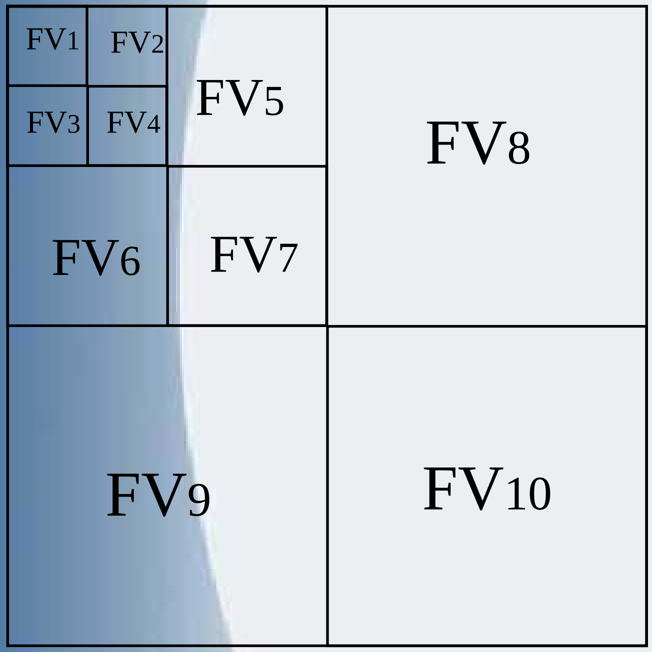


2D Wavelet Transform





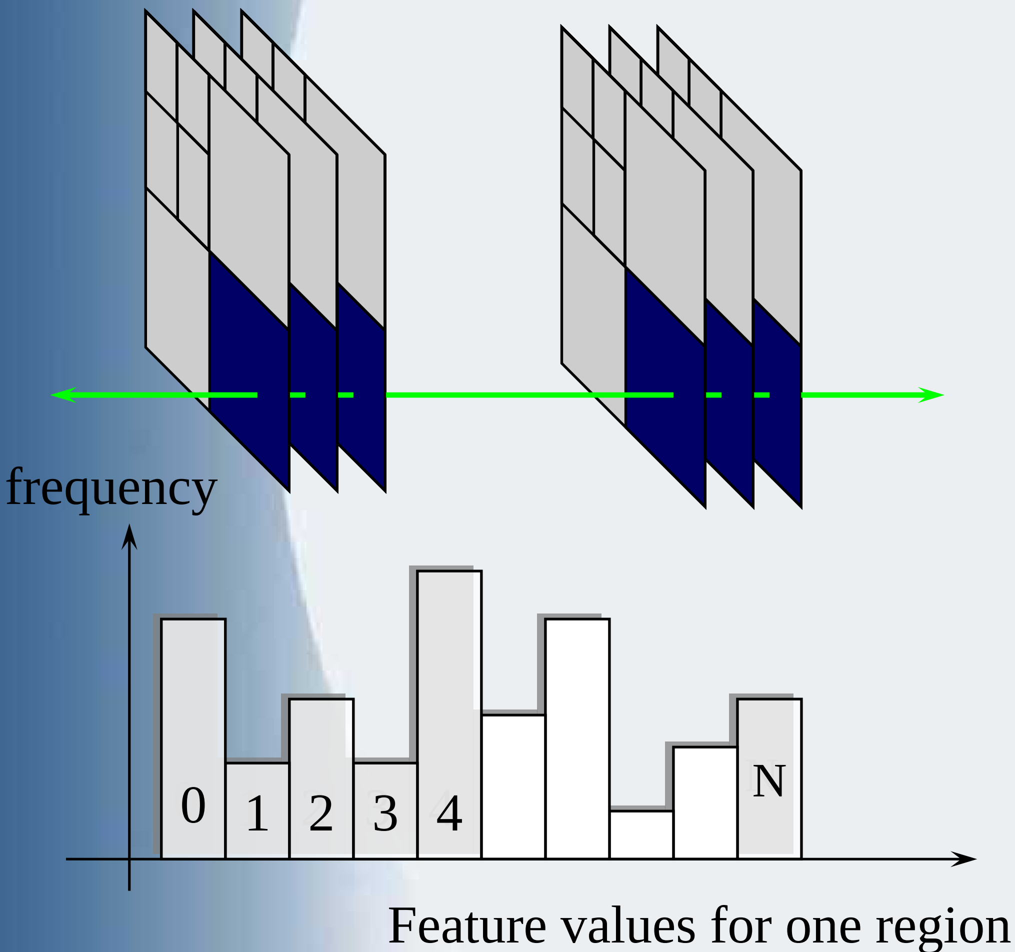
Indexing of Images



Steps:

- Apply wavelet transform to each image
- For each region compute a feature value

Class (bucket) Construction



- Construct a histogram using the same region for each image.
- Determine similar images according to feature value.
- Assign class names or numbers to each image.

Feature Vector Computation

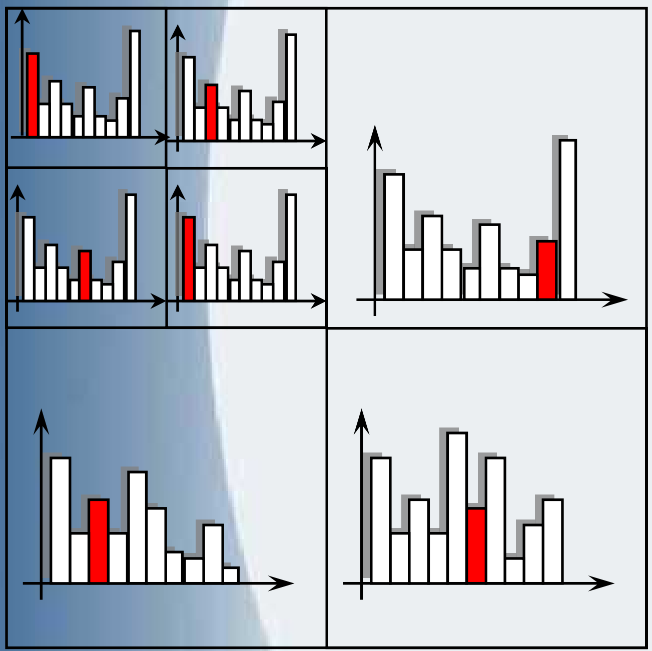


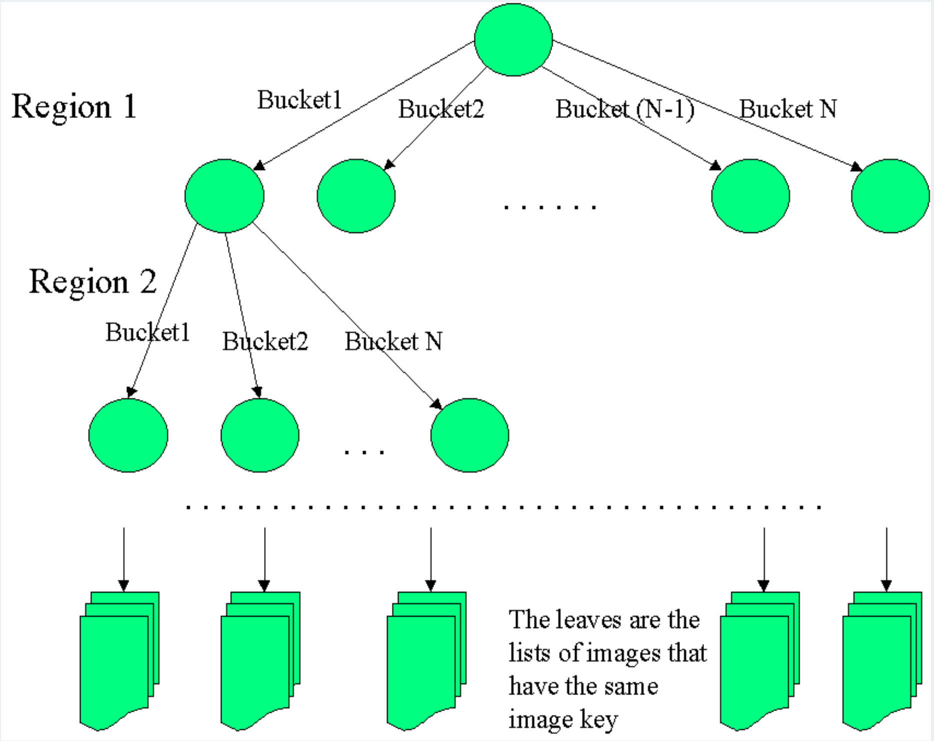
Image Key= | 1 | 3 | 6 |1 | 9 | 3 | 6 |

- For a specific image, a class number is obtained from each frequency

  sub-band.
- Class names are stored for future insertions and used in processing queries.

Index Structure

- K-ary tree structure
- Leaves contain sets of similar images.
- Tree traversal is governed by the feature vector



Properties of Indexing Method

- Images are classified at each frequency sub-band.
- The bucket mechanism allows distribution of images over an index function.

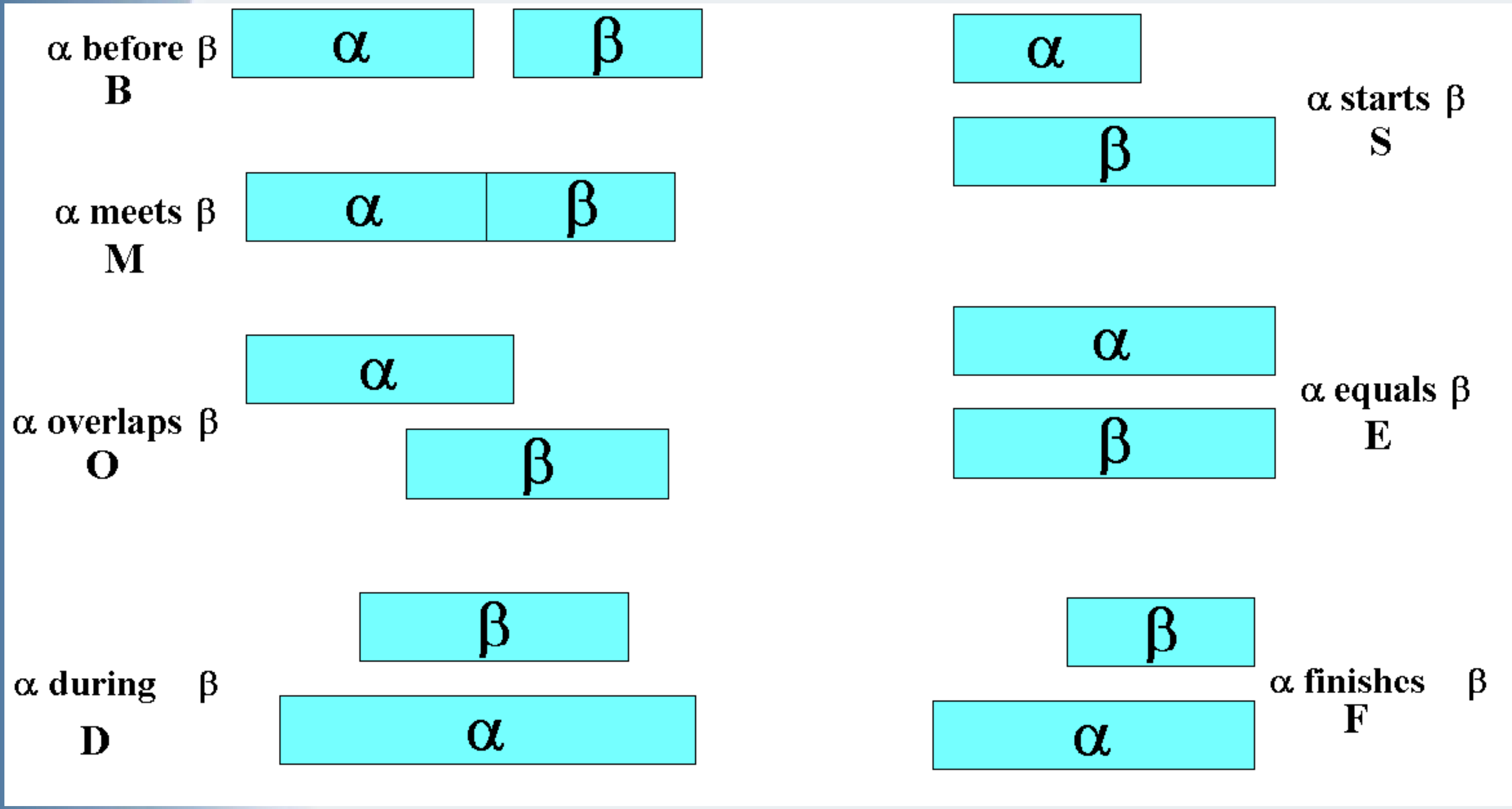
Study “Knowledge-Based Image Retrieval with Spatial and Temporal Constructs’, W. Chu et al

IEEE TKDE Nov/Dec 1998

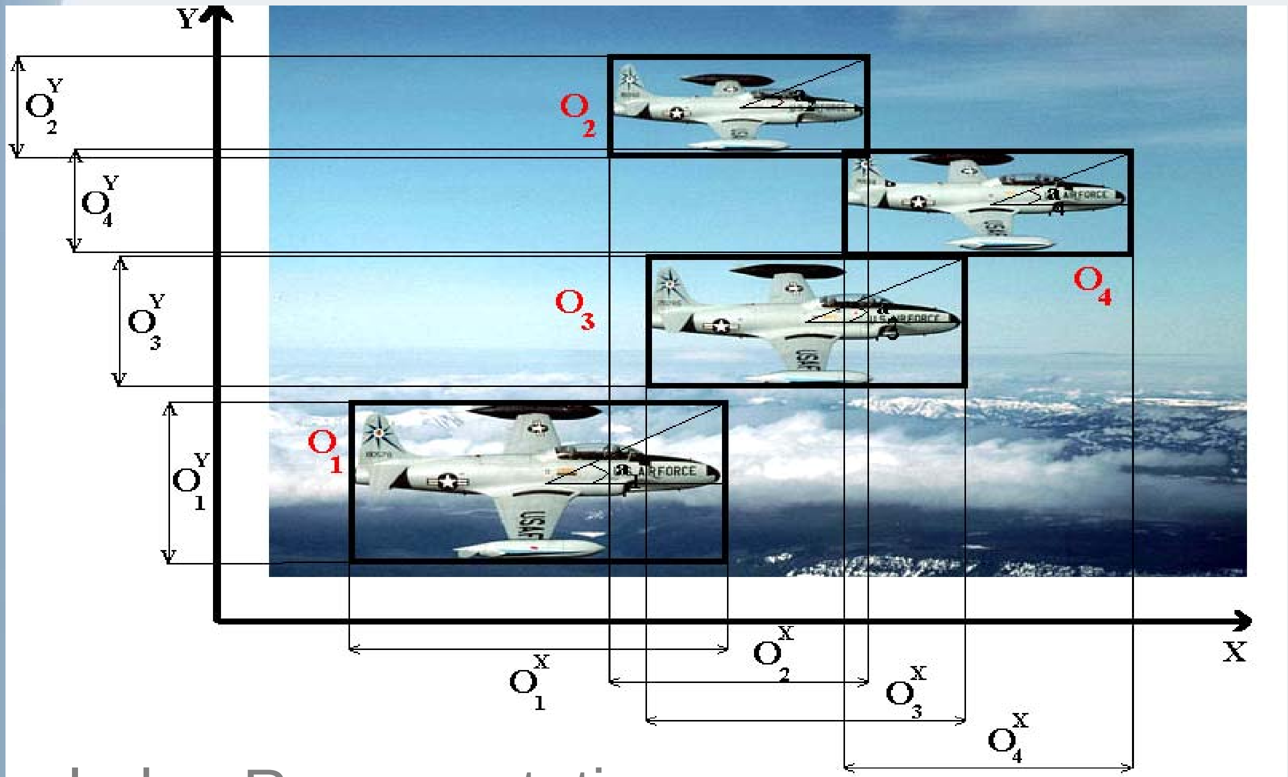
Spatial Semantic-based Search

Spatial semantics: Arrow formation

Binary Spatio/Temporal Relations



Example of Spatial Meta-Knowledge



Meta-Knowledge Representation:

O $(O_1^x, O_2^x, O_3^x, O_4^x, \tau_{12}, \tau_{23,} \tau_{13\,,} \tau_{34})$ ^ **B** $(O_1^y, O_3^y, O_4^y, O_2^y, \tau_1, \tau_2, \tau_3)$