Bases de données avancées

Bases de données multimédia

Université de Cergy-Pontoise

Master Informatique M1

Cours BDA

Multimedia DB

- Multimedia data include images, text, video, sound, spatial data
- Data of large volume; their use is widespread
  - Photos, personal videos
  - Digital television, online music
  - Web pages (text, images, video, sound)
  - Maps, directions, GPS
- "non-traditional" data requiring special management incompatible with conventional DB
  - Very weak structure (image, sound, video, text) or very specific (spatial)
  - Specific methods of access / modification
- The special case of image DB

Images

- Unstructured content
  - Matrix of dots (pixels)
  - Each point color information
- Further comments
  - Textual, structured, semantic ...
- Search images in a collection
  - needs
    - Detect objects in images
    - Summarizing a collection of images
    - Search images on various criteria (similarity, objects)
  - methods
    - Based on the annotations
    - Based on the content

Methods of image search

- By annotation
  - First method developed, using the text
  - Problem: how to annotate an image?
  - disadvantages
    - Ambiguity inherent subjectivity
    - Depends on the language and application
    - Expensive manual annotation
- The visual content
  - Basic idea: extract visual features (descriptors) and use the similarity of these characteristics?
  - Advantages: extraction program, language-independent, less choice problems and dependence on the application
  - Problem: the semantic gap = gap between the intention of the user and the search criteria used for annotation

Applications of content search

- Medical images: detection of pathologies
- Satellite Images: detection of object, meteorological phenomena
- Audiovisual: find a film plane or a character, copy detection
- Investigation: Fingerprint research, identification of a face
- Culture: seeking information about a work of art, e.g. monument from a photo
- …

Types of content-based search

- Search by Example: The mostly used
  - It gives a picture and seeks similar images in descending order of similarity
  - Variant: given an area of an image and find images containing similar areas
  - Generally it is satisfied with the k best answers (top-k)
- Search with relevance feedback
  - Extension that tries to reduce the semantic gap
  - Among the best answers, the user marks those that are not relevant
  - The system changes the similarity function to "stick" to the indication
  - several iterations

Image Descriptors

- Feature descriptor extracted from the image
  - Extraction method
  - Similarity measure

  Ex. color histogram
- Signature = vector representing a descriptor
  - Ex. components of the color histogram
- Images' space description
  - Multidimensional space where each signature is a point
  - Number of dimensions = number of components comprising the signature vector
  - Image similarity = signatures in the feature space are near

Types of descriptors

- Global descriptor
  - Approximate description of the entire image
  - Describes an atmosphere, an overall impression

  Ex. color, texture, shape descriptor
  - Produces a signature (point in the feature space) per picture
  - Large Feature space
- Local descriptor
  - Accurate description of parts of the image
  - Suitable for objects (parts of images)

  Ex descriptor areas, points of interest
  - Produced several signatures picture
  - Feature space of smaller size

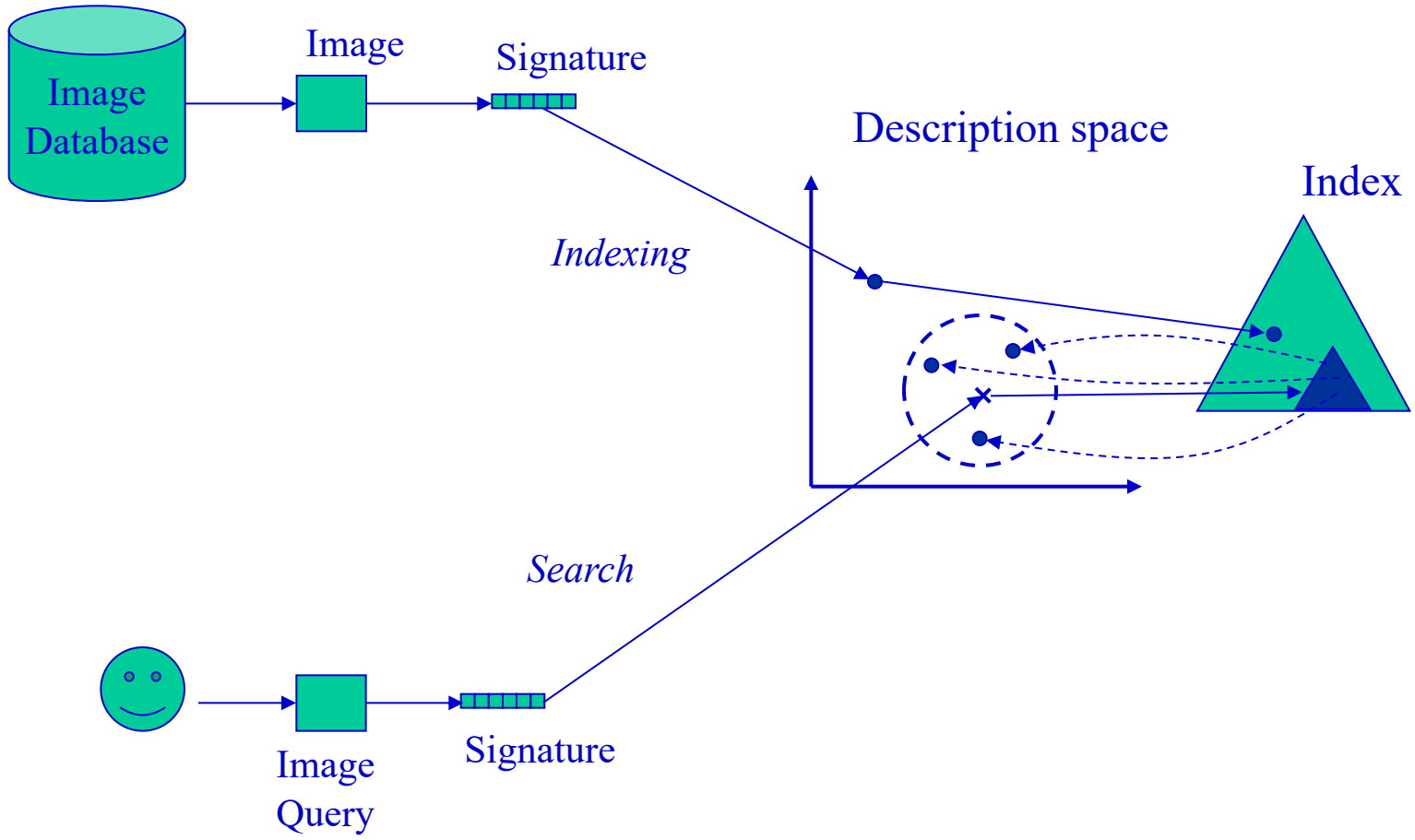
Example: color histogram

- Space representation of color (eg RGB)
  - Each color represented by the intensity values of the components
  - Objective: two colors close to the eye have close representations
- Sampling colors in the image
  - For eg RGB 24 bits (8 bits = 256 levels per component)
  - Sampling of 6 values component → 6^3=216 colors
  - Choice values: eg levels 0, 256/6, 2 * 256/6, ..., 5 * 256/6
  - Result: Histogram of 216 colors = 216 vector elements
- Example of calculating the color histogram
  - C for each color among the 216 colors of the histogram as the percentage of pixels of the image with a color "near" c
  - Histogram vector = 216 values between 0 and 100

Indexing of Images

- Index = data structure that allows to accelerate search
- General Idea: organize points in space description to quickly find the nearest neighbors of a given point
- Same type of problem in conventional DB
  - Given a value, find the objects in the database that match this value
  - The index allows not to browse the entire database
- ... But it needs special index structures
  - multidimensional space
  - Similarity search, no exact match

Architecture of an image storing/querying system



The curse of dimensionality

- For a point in the feature space, the index should allow to quickly find neighboring images… but in a multidimensional space there are problems!
- Main problem: the points tend to be equidistant
  - When we seek the neighborhood of a point is recovered either nothing or almost all BD!

  →index no longer useless, as do a sequential scan
  - The problem increases with increasing number of dimensions
- Solutions
  - Reduce the number of dimensions of local descriptors, project spaces of smaller size (eg find separately on groups of dimensions of the color histogram and merge results)
  - Approximate search by hash (LSH)
  - Classification (interactive) points for a given query

Index Types

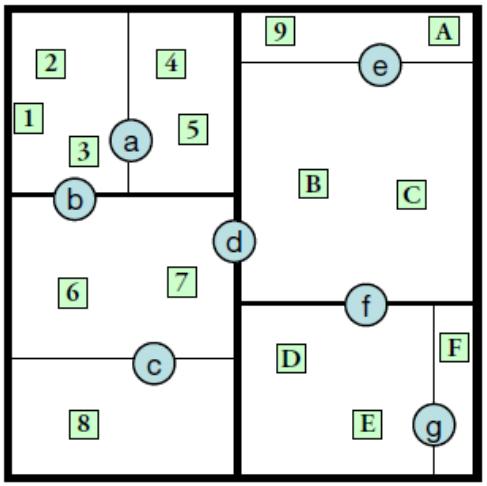
- General Idea: group of close points in bundles, packages super-packets, etc.
  - A hierarchy of packages we obtain = tree
  - neighboring points→ in the same package, super-package, etc..
- Most of the time:
  - Space Division
    - Division of the feature space into zones, areas into sub-areas, etc.
    - Product division of the data→ paquet = packet zone points
  - Data Division
    - Dividing the data into packets, packets into sub-packets, etc.
    - A subdivision of space→ zone = region (bounding sphere) package containing the points

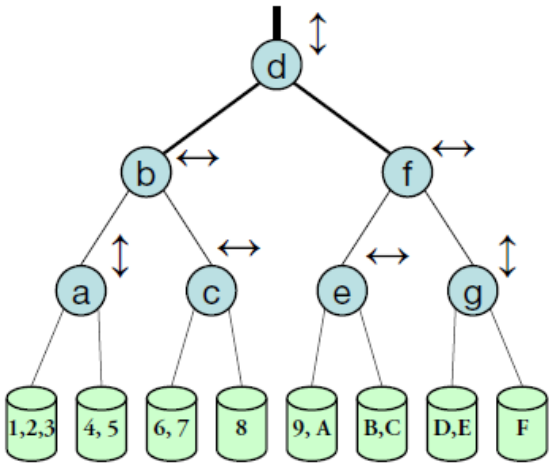
Example Index: KD-tree

- Division of space according to each dimension
  - At each step a size and pivot value is chosen
  - The two sub-areas continue recursively for each
  - It stops when the number of points of an area is under a given threshold

Example: points in a 2D space

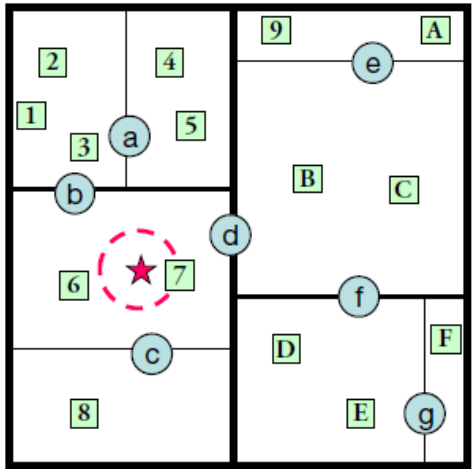
(source: thesis Eduardo Valle, "Local Descriptor for Image Matching Identification Systems)

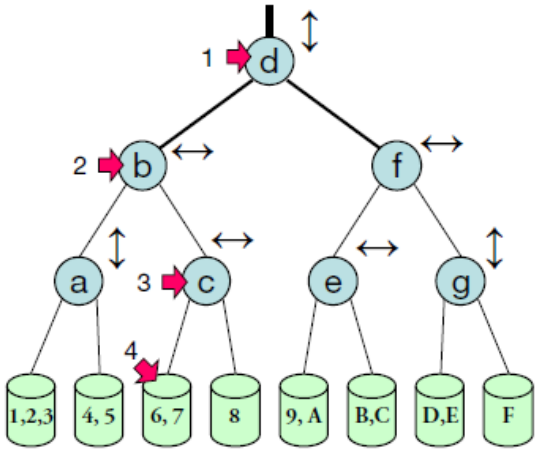




Search with KD-tree

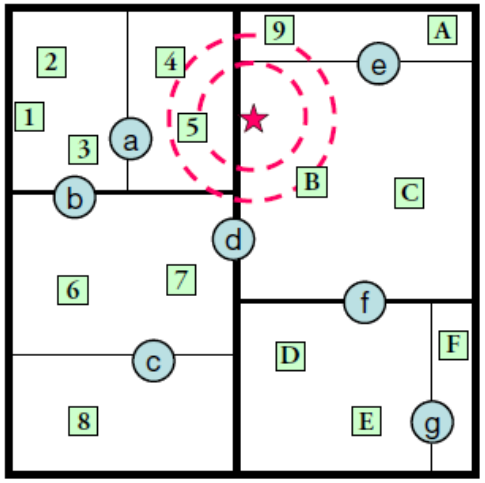
- Simple case points in a single zone
  - Depth-first traversal from the root
  - The coordinates of the motion guide the course

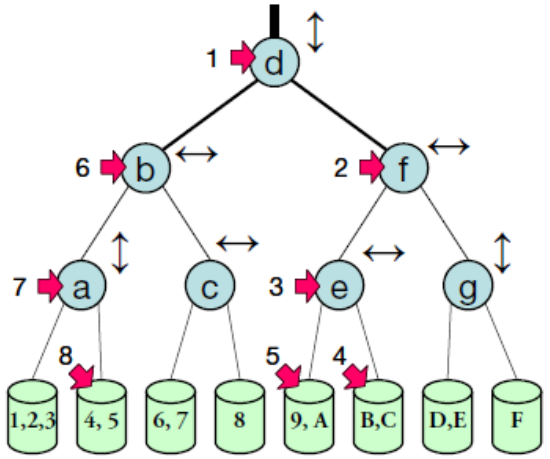




Search with KD-tree (continued)

- More complex cases: points in several areas
  - The depth-first traversal can follow several paths
  - Can possibly give priority to the most interesting areas





SQL and multimédia

- Multimedia in the relational database
  - Consideration from SQL3 and object-relational model
  - General Idea: introduction of types of multimedia objects with properties / methods specific
- Standard SQL / MM (2001), several types multimedia
  - *FullText*: text (words, phrases, stemming, ...)
  - *Spatial*: spatial and geometric data
    - Types: ST_Geometry, ST_Point, ST_Curve, ST_MultiPolygon ...
  - *Still Image*: Image
    - Types: SI_StillImage, SI_ColorHistogram, SI_Texture, ...

Multimédia in Oracle

- Extension *interMedia*, named *Oracle Multimedia* found in version 11g
- Data Types
  - Adaptation of SQL type / MM in Oracle
    - Four types: ORDAudio, ORDDoc, ORDImage, ORDVideo
    - Type ORDDicom dedicated to medical imaging (DICOM)
    - Type ORDSource for storing multimedia content
  - ORDImage = content (ORDSource) + image properties
    - Properties: size, content size, format ...
    - Metadata stored in the content, standard formats (XMP, EXIF) based on XML
  - Oracle also supports type SQL / MM Still Image
- Key Features
  - Storage: in a BLOB or outside of DB
  - Modification of content and properties
  - Signature extraction and metadata from the content
  - Research on properties, metadata and content

Image search in Oracle

- approaches considered
  - By the attributes that accompany the image in the database tables
  - By the properties of the image (size, format, ...)
  - By XML metadata
  - The content from the signature image
- Search by content
  - Signature images: *ORDImageSignature*
    - Contains descriptions of color, texture and shape as BLOBs
    - Methods to extract the signature of an image, measure the similarity of two signatures
  - Special index for signatures *ORDImageIndex*
- Problem: image descriptors imposed

Sources

- *Cours BD multimédia*, Valérie Gouet, CNAM Paris
- *Local-Descriptor Matching for Image Identification Systems*, Eduardo Valle, thèse de doctorat, 2008
- *SQL Multimedia and Application Packages (SQL/MM)*, Jim Melton, Andrew Eisenberg, 2001
- Oracle Multimedia User's Guide / Reference 11g
- Oracle interMedia Reference 10g