Image Databases
INLS 623
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What is an image database?

- Definition - a collection of image data, typically associated with the activities of one or more related organizations

- Focuses on the organization of images and its metadata in an efficient manner
  - Sometimes delves more thoroughly into an image's content
    - query by an image's characteristic rather than just keywords/tags

- Consumer, professional, and industry software available
Characteristics of Image DB

- Efficiently store images in database
- **Data modeling:** An image data model must be developed to deal with the issues of representing image in database.
- **Support image manipulation in database level:**
  - crop
  - resize
  - etc
- **Store metadata to image**
Why would you want an image database?

**Manageability**
- Images stored in the database can be directly linked with metadata

**Security**
- Fine grained security is possible. Access to an image can be restricted to individual users and it also offers other restriction controls.

**Backup/Recovery**
- Backing up the database will backup every image so it simplifies the process. Only one recovery procedure needed in an event of failure

**Extensibility**
- An image can be converted from one format to another. Metadata can be extracted from it. It can be copied, resized and the image quality controlled

**Flexibility**
- Sets of images can be deleted, updated or copied as easy as it is to write a query. Images can be linked together and metadata can be easily attached to them. All data related to an image or set of images can logically co-exist
Standards

Content-Based Image Retrieval (CBIR) - addresses problem of searching for digital images in large databases
- The search analyzes actual contents of the image (colors, shapes, textures, etc derived from image itself). This eliminates the dependency on metadata such as captions/keywords.

SQL/MM Still Image
- Part of SQL/MM Standard
- Multiple formats: JPEG, TIFF, GIF, etc
- Can scale, crop, or rotate an image as well as create a thumbnail
- Image-specific functions to search by image content rather than its metadata
  - SI_AverageColor
    - imagine wanting to find an image primarily green to be used in advertising outdoor furniture
Standards - Metadata

EXIF (EXchangeable Image File)
- JPEG, TIFF, RIFF WAV

IPTC (International Press Telecommunications Council) IIM (Information Interchange Model)
- Nearly universal acceptance
Standards Needed

File formats controversy
- Camera makers use proprietary file formats which causes problems when trying to develop a standard
- Vast number of file formats - JPEG, TIFF, GIF, BMP, etc.
- Hard to just use one as a standard because multiple formats are commonly used.

Storing thumbnails vs. dynamically creating thumbnails
- Storing can quickly view images without calling the original (often large) file at the cost of storage size and data redundancy.
- Creating thumbnails at middle tier will avoid making a thumbnail for every image and only dynamically create them when required at the cost of performance.
Images in Popular Database Solutions

Databases with image support:
- Oracle
- MySQL
- SQL Server
- Access 2007

These solutions offer some basic image support (BLOB), but merely as an image collection with metadata attached to images. It does not allow for query based on image content.

The above-mentioned popular databases encourage users to only have links in the database to images and not host the image itself. *The exception is [Oracle](https://www.oracle.com) and its 10g/11g databases.*
Image Storage

- Object Relational Database
  - Traditional relational database: table is the first form, and attributes stored in table are atomic. Image is usually saved as external file.
  - Object relational database: allow users to define additional data types while remaining the relational model. (class, inheritance, polymorphism.)

- User-defined Abstract Data Type
  - `create type ImageInfoType (date varchar(12), location_latitude real, location_longitude real) // define an image data type, to store location information`
  - `create table locate_photos(photo_id integer, photographer varchar(20), photo blob not null, photo_location ImageInfoType) // define a table to store photos, the type of photo_location is ImageInfoType.`

- Binary Large Object
  - Image and video are physically stored as large binary data
  - Stored differently from other column value
  - However it is still manipulated as a single atomic field in a table record.
Image Retrieval and Manipulate

- **User-defined functions**
  - User-defined functions are equivalent to methods in the object-oriented context. It is used to define image operations on those user-defined data types.
  - DB2 and Oracle even support user-defined functions written in C or Java programming languages.

- **Extended SQL Query**
  - ORDBMSs extend the basic SQL language to allows UDFs to be called directly within SQL queries.
  - select photographer, convert_to_grayscale(photo) from locate_photos where within_distance(photo_location, '1', '30.45, -127.0');
Image Operation

- Import and export image
- Convert image format
- Scale image to different resolution
- Change compression type, black-white, gray-scale image inversion, etc.
- Content-based search: search by features, its distribution of color, people included in the image, taken location, device, etc.
current indexing techniques

- EXIF - file information
- IPTC - image metadata
- IPTCforXMP - extension of metadata
- IPTC G2-standards (XML)
Created Date: 05-01-14
Creation Time: 12:38:36 am
Dimensions: 2560 x 1920 pixels
Exposure Time: 0.100 (1/10)
JPEG Quality: Unknown
Aperture: f/3.3
Color Mode: Color
Date/Time: 05-01-14 12:38:36 am
Flash Used: Off
Focal Length: 63 mm
ISO Equiv.: 100
JPEG Process: Baseline
Camera Manufacturer: PENTAX Corporation
Metering Mode: Pattern
Camera Model: PENTAX Optio WP
Orientation: 1

Caption: August 14 2004 - The Road Cycling Event provided a picture-perfect backdrop of the Acropolis. Here, a general view of the 144 competitors in the men's cycling road race passing the temple of the Parthenon atop the Acropolis at the City Centre Cycling Road Race Course in Athens. In some ways, the course is a historical tour of central Athens, taking cyclists on a 17-lap 224.4 kilometer odyssey around the city's major landmarks. In this photo, the cyclists ride on Dionysiou Areopagitou street, past the Acropolis in Athens, Greece. (SteveCom Photo/Dimitri Papadopoulos/POOL)

Caption Writers: DP
Headline: ATHENS 2004 Olympics
Keywords: Road, Cycling, Athens, Olympic, Games, Olympiad, Olympics, Acropolis
Object Name: ATHENS 2004 Road Cycling
Transmission Ref: 011GCRATOLY200400014-1
Edit Status: Lead
Category: 1
Rights Usage Terms: Rights managed image
Special Instructions: EDITORIAL USE ONLY, ONE TIME USE ONLY, NO ARCHIVES. Photo also available in 3D Stereo. Photo also available in Kodachrome film slides.
Urgency: Normal
City: Athens
Location: Acropolis
State: Attica
Country: Greece
Time and Date: 1:36:31 PM, 8/14/2004
Photographer: Dimitri Papadopoulos
Title: POOL
Credit: Dimitri Papadopoulos/Newcom
Source: QuebecPress.com
IPTC Encoding: Im: Mac Roman

Sound: Play Stop
Save & < | Save & > | Clear Load... Save... Apply Stationary Fad Variables... Cancel OK
future indexing techniques

- Query by example
- Semantic retrieval

Content comparison techniques:
- Color
- Texture
- Shape
Trade offs

- **Database Size**
  - Image databases are comparatively bigger than traditional text databases
  - Indexing techniques further increase the database size

- **Performance**
  - As the size of the database increases, performance decreases

- **Complexity**
  - Managing image database and retrieving images is complex
Future image databases..

**Photobook** - MIT
- It works by comparing **features** associated with images

**VisualSEEK**
- joint content-based/spatial querying
- automated region extraction
- direct indexing of color features

**Blob World** - Berkley
- sophisticated color region searching

IBM's [Query by Image Content](http://querybyimage.com) (QBIC)
- color percentages, color layout, & textures
- QBIC in DB2 in Action @ [HermatigeMuseum](http://hermatige.com)
- etsy by color
Technology: IBM DB2 Image Extender

- DB2 Universal Database (UDB) is a product of IBM
- It offers the DB2 Image Extender as part of the DB2 UDB as Audio, Image and Video Extenders package
- The DB2 Image Extender defines the distinct data type DB2IMAGE
- The following SQL-insert statement shows how an image is stored into an image database
  
  ```sql
  INSERT INTO example (image) VALUES(
    DB2IMAGE (CURRENT SERVER, 'pisa.jpg', /* source_file */
      'JPG', /* source_format */
      1, /* 1=BLOB, 2=file pointer */
      'my Image File' /* comment */))
  ```

- In this example, the content of the image comes from a server file and stored as a BLOB in the database.
DB2 Image Extender .... contd

- Supports a variety of image formats like GIF, JPEG, BMP, and TIFF

- Creates and stores a thumbnail of the image. It is also used to retrieve a thumbnail or a full-size image

- Searches the images based on data that you maintain, such as a name, number, or description

- It can also search by data that the DB2 Image Extender maintains, such as the format of the image or its distribution of colors, etc.
Professional Examples

- **IrfanView**
  - Graphic viewer for professionals as well beginners
  - Thumbnail/preview option
  - Show EXIF/IPTC/Comment text in Slideshow /Fullscreen etc.
  - IPTC editing possible
  - Metadata can be edited after installing plugin IPTC.dll
  - It is free!!

- Disadvantage:
  - Does not allow editing EXIF
Professional Examples

- IrfanView contd...
Professional Examples

- PixFiler
  - It is a picture organizer
  - Fast and robust
  - Easy to categorize and annotate
  - Information can be retrieved from EXIF and ITPC metadata
  - Disadvantage:
    - It is not free :(
Professional Examples

- **ImageMagick**
  - Allows to read, write and manipulate images
  - Supports 89 image formats including TIFF, JPEG, PNG, GIF, etc.
  - Works well with Windows, Unix and Mac
  - Provides interface for programming languages like C/C++, Java, Perl, PHP and other
  - Biggest advantage is that interface can connect ImageMagick with DB2 Image Extender
  - ImageMagick is free!
Consumer Examples

- Facebook
- Flickr
- ImageShack

Most consumer examples are websites because of their remote accessibility, ease-of-use, and low to zero cost.

These examples are some of the most popular ones used today.
- ImageShack - most images on the web today

Consumer examples typically lack advanced search options such as querying by image content.
- Must search by image metadata - tags, captions, filenames, etc
Facebook

Changes saved.

Click here to share this album with friends, even if they're not on Facebook.
Industrial example

- Satellite Imagery in Earth Science Applications (Remote Sensing) Google Earth
- Medical Image Database: MedPix
- Oil industry: IESX
- Digital image catalog: ARTstor
Google Earth

Google Earth: image store, rotate, multiresolution display, 3-D models, etc.
MedPix

Store images of radiography, computed tomography (CT), magnetic resonance imaging (MRI)...
IESX

Used at oil industry for oil exploration: seismic survey and interpretation, strata imagery, etc.
ARTstor

Digital image library for educational purpose. Support for metadata integration, multiresolution storage, zoom, rapid retrieval, and integration with traditional database.
Questions?