Basi di dati multimediali

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- Materiale didattico:
  - Appunti
  - K. Selcuk Candan, M.L. Sapino "Data Management for Multimedia Retrieval", Cambridge University Press, 2010
  - Dispense e lucidi usati a lezione

Modalità di Esame

- 5 appelli all'anno
  - .. giugno 2018 e .. luglio 2018
  - .. settembre 2018
  - … dicembre 2018
  - Gennaio/Febbraio 2019
- L'esame consiste di una prova orale sugli argomenti visti a lezione (comprensiva di discussione dell'attivita' di approfondimento degli argomenti del corso)

Orario

- Lunedi' 16-18
- Giovedi' 14-16
- Venerdi' 9-11

Programma del corso

- Introduzione alla multimedialita' ed alle sfide tecnologiche che comporta
- Modelli per la rappresentazione di dati multimediali
- Indicizzazione di dati multimediali (multidimensionali)

- Clustering
- Interrogazione di basi di dati multimediali (gestione dell'imprecisione)
- Il relevance feedback
- Il web come bacino di dati eterogenei e multimediali

Starting discussions….

- What is media?

Starting discussions….

- What is media?
  - A means to communicate "information" in the most compact form
- Popular media
  - unstructured text, structured text (e.g., XML)
  - images (GIF, TIFF,JPG),
  - video (MJPG, MPEG),
  - Audio,
  - ….

What is media?

- Text/document
- Images
- Video
- Audio
- …..

- What is multimedia?????
- What is hypermedia????

What is media?

- Hypermedia brings together multiple media objects and allows users to interact with the collection to select relevant information.
  - Semantic heterogeneity
  - Resource heterogeneity
  - Interactivity

Sample application

- Police investigation…
  - Video data (surveillance cameras)
  - Audio data (telephone wiretabs)
  - Image data (surveillance, mugshots)
  - Document data (police reports)
  - Conventional data (bank records, employment records, police records)
  - Geographic data (maps)

Sample multimedia query

- "Find the records of every criminal who looks like the person seen in "surv_im.gif" and who had a bank transfer of more than $500,000 within the last 5 months. Return all police reports which mention such persons and their past accomplices."

Semantic Heterogeneity

- Spatial, temporal, hierarchical dimensions
  - modeling
  - specification
  - indexing,
  - retrieval, and
  - visualization methods
- User- and context-dependence, subjectivity
- Availability at various quality levels

Physical Heterogeneity

- Volume
  - storage,
  - delivery, and
  - processing
- Quality/cost trade-off
  - increases robustness, graceful degradation

Interactivity

- 100ms interaction deadline
  - resource allocation
  - prefetching/caching
- Subjectivity and personalization of content
- Interaction structure along with spatial, hierarchical, and temporal structures

What is a data model?

What is a data model?

- A set of constraints that describe
  - the structure and behavior of the data
- The roles of data models are
  - to enable description of data (conceptual)
  - to enable storage of data (physical)
  - to enable validation/redundancy removal of data (logical)
  - to enable retrieval of data
    - comparison, indexing, and query processing

Different type of data models?

- Physical data models
  - describe how the data is stored on the disk
- Conceptual data models
  - describe the real world
- Logical data models
  - intermediary between physical and conceptual models

Queries

- Metadata queries
- Example queries
  - Exact
  - Partial match
- Object queries
  - visual similarity
  - semantic similarity
  - spatial similarity

What is an image?

- 2D matrix of values
- Collection of objects and their spatial relationships
  - An object is an entity within an image
    - visual
    - semantical
- A feature vector
  - Eg. histogram of colors

What is an image database?

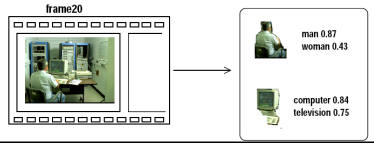
- A collection of images
  - local or web
- A query processor (indices etc.) which
  - maps user query into data model
  - retrieves the relevant images
- An information visualization system which shows results to the user

Why "image" database?

- Size of data
- Properties of data
  - Visual: image processing
  - Semantical: users, context
- Similarity-based retrieval
  - similarity-based query processing
  - new index structures
  - relevance ordering
- Query language
  - How to let users specify what they want?

What kind of images?

- Mug shots, cat-scans, finger prints
- News, advertisement, family photos
- Surveillance
- Video frames



What are the features that may interest us?

- Colors, color histograms
  - "sunny day", "sea"
- Edges
  - "maps", "aerial surveillance"
- Texture
- Image segments
  - shape,location, color
- Objects
  - visual features, semantics
- Metadata, captions

What kind of queries?

- Find all images created by “John Smith”
- Find all images which look like “im_ex.gif”
  - Find me top-5 images which look like “im_ex.gif”
- Find all images which look like “sketch.bmp”
- Find all images which contain a part which looks like ….

What kind of queries?

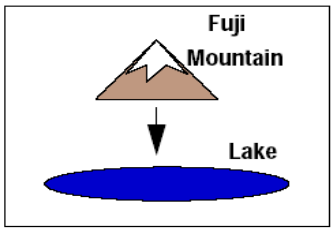
- Find all images of sunny days
  - advertisement
- Find all images which contain a car
- Find all images which contain a car and a man who looks like”mugshot.bmp”
  - surveillance
- Find all image pairs which contain similar objects
  - data mining

What kind of queries?

- Find all objects contained in images of sunny days
- Find all images which contain two objects
  - first object looks like “im.gif”
  - second object is a car
  - first obj. to the right of second obj.

  and return the semantics of these two objects.

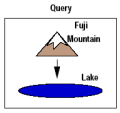
QBE (visual representation)

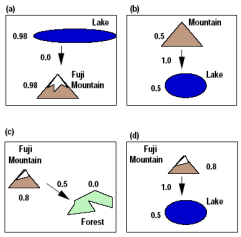


Example

select image P, *object* object1, *object* object2
where P *contains* object1
and P *contains* object2
and object1.semantical_property *s_like* "mountain"
and object1.image_property *image_match* "Fuji_mountain.gif"
and object2.semantical_property *is* "lake"
and object2.image_property *image_match* "lake_image_sample.gif"
and object1.position *is_above* object2.position

Query…and results…





Relational databases (??)

- Business applications
- Data model is relational
- Queries are exact/declarative
- Updates are important
- Concurrency is important

Shortcomings…

- Image data doesn't fit into tuples
  - Media data need to be kept separately
- No image comparison
- No partial match processing
- No ranking
- Not computationally complete
  - Media processing requires more computational power.

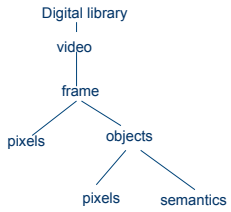
Solutions

- Use a host language and embed database queries in it (relational approach)
- Provide more computational power in the data model itself (object-oriented approach)

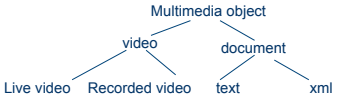
Other problems?

- It does not capture the semantical structure of the data well
- Hierarchies:
  - Aggregation hierarchy
  - Inheritence hierarchy

Aggregation hierachy



Inheritance hierarchy



Object-oriented data models (logical)

- maps "entities" to data structures
- maps "behaviors" to functions
- relationships can be described as
  - object references or
  - separate entities.

OODB

- Object oriented databases provide
  - Higher computational power
  - Aggregation hierarchies
  - Inheritance hierarchies
- They model the real world better!
  - Everything is an object
- You can define your own external methods

E.image_similar_to (c.image)

Shortcomings…

- Too much overhead
  - Optimization is hard
- No partial match processing
- No ranking
- Query processing is cost driven
  - not "similarity" driven

Object Relational Databases

- Benefits from both
  - Relational technology
    - tuples
    - SQL
  - Object technology
    - User definied functions
    - User defined abstract data types (ADTs)

Shortcomings…

- No partial match processing
- No ranking
- Query processing is cost driven
  - not “similarity” driven

What else?

- Deductive databases
  - Logic based
  - Boolean queries
- Fuzzy/probabilistic databases
  - usually logic-based, but not boolean
  - nothing is *true* or *false*
  - results are not-exact (like multimedia queries)

What else?

- Spatial/Temporal Databases
  - Scientific, geographic applications
  - Data model is vector or interval based
  - Queries
    - Range queries
    - Nearest neighbor queries
  - Queries are declarative or visual

What else?

- Data mining
  - Business, scientific applications
  - Relational data model
  - Queries: find
    - patterns,
    - rules,
    - classes, or
    - outliers

What else?

- Semi-structured data management
  - Most data has a well-defined structure (schema)
  - In SSD, there is no common schema
    - each object describe itself
- Queries
  - Structure-based

…and

- Image databases
  - Data model is feature-vector based
    - Multiple features
      - Color
      - Texture
    - Each feature represented as a vector space
  - Structure may or may not be available
  - Queries
    - Query-by-example
    - Ranking
    - Feedback (user-to-system, system-to-user)

Research Issues

- Data model
  - Content, features of interest
  - Information extraction/integration
- Query Language
  - matches the data model
  - captures user's interest

Research Issues

- Query processing
  - Online vs. off-line information extraction
  - Indices for different media
  - Optimization of queries with different media
  - Similarity-based retrieval, ranking
  - Relevance feedback