Research and Development of Multimedia Data Management System (MDBMS)

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Agenda

- Motivation and Challenges
- Prototype MDBMS System
- Applications
  - Social Networking
  - High-level Feature Extraction
  - Storm Surge Animation Model
  - Florida Public Hurricane Loss Model
Motivation and Challenges

- Why multimedia data popular?
  - Attractive
  - Informative
  - Compact
  - Cheap memory makes storage easy

- Why handling and representing multimedia data challenging?
  - Huge size (a typical 10 sec MPEG video ~4M)
  - Temporal and spatial information
  - Semantic meaning
  - Multidimensional representation

- Why a separate database management system for multimedia data?
  - Traditional database incapable of accommodating above characteristics efficiently
Three Research issues in Multimedia Database Management System (1)

A. Storage and Representation: query efficiency and accuracy depends on optimum storage and representation
- Leads to investigation in feature selection and indexing
- Conflicting Issues
  - Greater the feature space, more accurate the query result
  - Greater the feature space, greater the computation overhead

Thus, we need
- Efficient Indexing supporting varied multimedia retrieval
- Optimum feature selection to represent semantic, temporal and spatial information
Motivation and Challenges (Cont.)

Three Research issues in Multimedia Database Management System (2)

B. Query and Retrieval: temporal, spatial and semantic content should be considered during query of multimedia data

- Leads to investigation in Image and Video retrieval strategies
- Leads to investigation in concept identification and event detection via multimedia data mining

Eg. Key word based query: **Sunset**
Motivation and Challenges (Cont.)

Three Research issues in Multimedia Database Management System (3)

C. Multimedia System: integrated and robust system should be developed to address the nuances of multimedia data

- Leads to investigation in developing an unique prototype to integrate the complex characteristics of multimedia data
  - Presentation
  - Authoring
  - User Feedback
  - Data Security
  - Web-Based Multimedia Search
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  - Soccer Event Detection
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Prototype MDBMS System

- **Motivation:** The distributed multimedia management system design requires a comprehensive and integrated framework, which
  - Employs distributed architecture for the large-scale multimedia management system
  - Offers a database modeling solution to manage the complicated multimedia databases
  - Facilitates content based retrieval
  - Incorporates the innovative techniques to further refine the retrieval performance
  - Delivers appealing experiences on multimedia presentations to all the users
  - Ensures the security assurance for multimedia data access
Prototype MDBMS System (Cont.)

- Proposed Framework

**Server Side**

- Network Layer
  - TCP/IP
  - UDP
  - RTP
  - HTTP
  - ...

**Client Side**

- Request Handler
  - Request Packager
  - Request Sender
  - Information Receiver

- Multimedia Browsing and Retrieval Module
  - Video Browsing
  - Video Retrieval
  - Image Retrieval
  - Online Media Retrieval

- Presentation Authoring and Rendering Module
  - MATN Model Design
  - SMIL Generator
  - Java Media Frame Player
  - Web based Player

- Security Management Module
  - User Roles Manage
  - Object Role Manage
  - Environment Role Manage
  - Security Rule Manage

- Security Checking

- General User
- User Log In
- Administrator
Prototype MDBMS System (Cont.)

Server Side

PostgreSQL: Multimedia Database Management (Relational Object Database)

- MMM & HMMM
- Source Data: Textual Data, Images, Audios, Videos
- Processed Data: Segments and Objects, Multimedia Meta Data, Visual/Audio Features, Affinity Relationships

- Multimedia Database Indexing


- Modeling Multimedia Data Relationships

Multimedia Search Engine

- Image Retrieval
- Video Retrieval
- Online Learning
- Video Clustering
- Offline Learning

Request Handler

- Receiver
- Data Sender

SMARXO Security Control

- Multimedia Data Processor
- Security Policy Checker

Multimedia Data Manager

- Multimedia Data Analyzer
- Multimedia Data Supplier

Network Layer
Prototype MDBMS System (Cont.)

- Modified PostgreSQL’s index mechanism to include AH-Tree
  - Efficient multimedia data retrieval in a commercial DBMS
  - Allow nearest neighbor queries (KNN)
- Modeling multimedia data relationships (Social networking)

![Diagram of Multimedia Database Management - PostgreSQL]

- Source Data + Processed Data (MMM & HMMM)
- Multimedia Database Indexing (AH-tree)
- Modeling Multimedia Data Relationships
Prototype MDBMS System (Cont.)

- **Modification of PostgreSQL’s indexing mechanism**
  - PostgreSQL’s index algorithm based on GIST was changed to have the functionalities of AH-Tree
    - Added index key of AH-Tree
    - Modified insert algorithm
    - Modified search algorithm to allow KNN queries
    - Adjusted the insert and search algorithms of AH-Tree to be robust to concurrency
Prototype MDBMS System (Cont.)

- **Functionalities:**
  - Content-based image retrieval
  - Video browsing and retrieval
  - Presentation and authoring
Prototype MDBMS System (Cont.)

- Content Based Image Retrieval
Prototype MDBMS System (Cont.)

- Video Browsing and Retrieval
Prototype MDBMS System (Cont.)

- Presentation and Authoring
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Social Networking

Social networks are huge and growing

- Facebook: ~200 million
- LinkedIn: ~35 million
- Twitter: ~12 million

Visualization of Social Data

Social Networking (Cont.)

- Visualizing Large Social Networks

### Issues
- Size of the network
- Performance issues during layout
- Viewability and Usability decreases
- Difficulty in analyzing the network

### Solution approaches
- Reduce number of nodes
- Maintain network characteristics
- Maximize similarity between original and represented networks
Social Networking (Cont.)

- Existing Solutions

- Using semantic information associated with data (content-based)
- Identifying disjoint clusters
- Using structural information of data (structure-based)
- Represent clusters as glyphs or compound graph
- Discovering groupings/classes in data
- Use node metrics
Social Networking (Cont.)

Discussions

- Issues of Clustered Graph representation
- Determining the cluster size
- Preserving overall structural similarity/equivalence
- Determining the representative nodes
- Preserving the network characteristics
Social Networking (Cont.)

- Proposed Approach

1. Node Filtering: Pick nodes based on network structure/user choice
2. Determine Node Metric: Calculate structural and semantic metric
3. Similarity Calculation: Calculate structural and semantic similarity
4. Node Assignment: Assign filtered nodes to original nodes to maximize overall similarity
5. Generate the representative graph

Graph Layout
The lines between images represent the similarity relationship between them.
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TRECVID High-level Feature Extraction

❖ TREC conference
  ❖ Research in information retrieval
  ❖ TRECVID: independent track created in 2001

❖ TRECVID
  ❖ Research in automatic segmentation, indexing, and content-based retrieval
  ❖ Large test collection (videos) and uniform scoring procedures
TRECVID High-level Feature Extraction (Cont.)

- **TRECVID Tasks**
  - High-level feature extraction
    - High-level semantic concept (e.g., people, indoor/outdoor, speech, etc) detection
  - Search (interactive, manually-assisted, and/or fully automatic)
  - Surveillance event detection
  - Content-based copy detection
TRECVID High-level Feature Extraction (Cont.)

- **High-level Feature Extraction**
  - Automatically identify the occurrence of high-level concepts (Indoor/Outdoor, People, Speech, etc) in test video data

- **Data**
  - Model-development data: 200 hours of video
  - Test data: 180 hours of video

- **Multimedia Framework**
  - Feature Extraction
  - Normalization, Discretization
  - Subspace Analysis
  - Classification
TRECVID High-level Feature Extraction (Cont.)

- **Next Step:**
  - The techniques of the High-level Feature Extraction task serve to help video search
  - Search Task (interactive, manually-assisted, and/or fully automatic)
    - Apply features of our multimedia management system, such as event detection
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Storm Surge Animation Model

- Storm Surge Animation Environment

- Lidar measurements
- Feature extraction
- Photographs
- GIS databases
- Digital terrain model
- Building
- Vegetation
- Road
- Data assimilation and representation
- Visualization environment
- Animation component
- Numerical models

\[ \nabla H \cdot \vec{V} + \frac{\partial w}{\partial z} = 0 \]
Storm Surge Animation Model (Cont.)

- Virtual Terrain Project

Simulator
3-dimensional
Interactive
Open-source
Engines
Storm Surge Animation Model (Cont.)

*LIDAR*

- Airborne
- Light detection
- Topographic data
- Accurate
- High resolution

Morphological filtering
Man-made structures
Footprints
Procedural construction
Storm Surge Animation Model (Cont.)

- **Engines**

- **Sky**
- **Wind & Rain**
- **Marine**
- **Vegetation**
- **Traffic**
- **Storm Surge**
Storm Surge Animation Model (Cont.)

- **Storm Surge Simulator**
  - Simulate surge flooding effect by manipulating water mesh plane.
  - Water height are taken from NOAA hourly numerical surge estimation.
  - Displaying a new height every 10 seconds.

*NOAA hourly water height estimation*

1,3,6,7,8,5,4,8...

- Storm surge engine
- Time Engine
- Adjusting water mesh height
- Synchronized sunlight
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Florida Public Hurricane Loss Model

Introduction

- Florida Public Hurricane Loss Model is funded for $4.3 million by Florida Office of Insurance Regulation.
- The objective of the project is to develop and maintain a computer model to assess hurricane risk and to project insured losses due to the occurrence of hurricanes in Atlantic Basin.
Florida Public Hurricane Loss Model (Cont.)

- **FPHLH Framework**

![Flowchart showing the components of the Florida Public Hurricane Loss Model](flowchart.png)

- **Statistical Program**: Met Data, Bldg Stock Data, Engr Data, Insurance Data
- **Wind Model**: Terrain Data
- **Vulnerability Model**: GIS Data
- **Insured Loss Model**: Exposure Data
- **Output**

**Computer Platform**: Fortran, C++, Java, IDL, Matlab, ArcGIS, Oracle 9i
DMIS (Distributed Multimedia Information Systems) Laboratory

- Currently 9 Ph.D. students and several undergraduate students
- 4 Ph.D. students graduated. Two obtained tenure track assistant professor positions at reputed US schools (U. of Alabama at Birmingham and U. of Montana). One works at eBay (first job after graduation) and another one works at State Street (Assistant Vice President), USA
- 18 MS students graduated with placements at Microsoft, IBM etc.
- Research areas:
  - Distributed Multimedia Database Systems
  - Multimedia Data Mining
  - GIS and Remote Sensing
Dr. Chen is the Editor-in-Chief of International Journal of Multimedia Data Engineering and Management (IJMDEM)

- Most Active SMC Technical Committee Award, IEEE Systems, Man, and Cybernetics Society, October 2006
- Outstanding Contribution Award, IEEE Systems, Man, and Cybernetics Society, August 2005
- The Inaugural Florida International University Excellence in Graduate Mentorship Award, 2006
- 2004 Florida International University Outstanding Faculty Research Award
- SCIS Faculty Research/Service/Mentorship Awards
- SIRI Fellow

Best Paper Award, IEEE International Symposium on Multimedia (ISM2006), December 11-13, 2006, San Diego, CA, USA.
Thank you

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