The future of Multimedia Web Search Engines

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Why searching multimedia content?

- Digital data explosion on the future internet (990 EB by 2012): 99% in multimedia format
- User problem: find useful information -> need of effective Multimedia Search Engines
- Personalization: effective way to cope with the multimedia content flood on Internet: e.g., personalized news, personalized AV, personalized contacts (social nets)
- Basic functions: searching and filtering
The “current” wisdom

• Current engines search multimedia data according to associated text and flags
• Search is important for online advertising: Global advertising business (~$500B) vs. packaged software business (~$200B)
• Web 1.0 Multimedia Search: limited online advertising
• Web 2.0 Multimedia Search: potentially new opportunities for online advertising and applications
The “current” wisdom - 2

• How Search Engine Achieves Scalability?
  – Complexity: $O(n) \rightarrow O(\text{const})$
  – Key factors:
    • Inverted index (Vocabulary size $<<$ document number)
    • Cache (small index + big index)

• Convert multimedia search to document search (use inverted index)

• Use the same Mega-Datacenter of current Search Engines
Similarity Searching & Filtering

• Effectiveness
  – the way of formulating the similarity measures: a model of human perception

• Efficiency
  – the way of achieving the required performance over huge volumes of data – index structures
Let's consider the case in which we are searching for a mountain with a lot of snow on it.
Searching for: mountain

Page #2

The user can browse the results coming from the text search.

We have to go to page #2 to find a photo similar to what we are searching for.
The user can browse selecting always the image that is more relevant for his/her needs.

Now the user is probably happy.

However, what about searching for a particular mountain?
Searching for: Mont Blanc

The user is interested in photos about Mont Blanc.

What kind of photo is the user searching for?
CONTENT-BASED

Query selected from results obtained for Mont Blanc

Results are nice, but obviously not all of them are about Mont Blanc.
The results are all about Mont Blanc.

Is it true?
COMBINED

Query selected from results obtained for Mont Blanc

Text: Mont Blanc

The results are all about mont blanc.

Is it true?
Face Recognition

Query

VideoFrame

2° result
Music Modelling

audio recording

feature extraction

HMM modelling

index

\[ F_{n-1} \quad <Audio> \quad ... \quad </Audio> \]

\[ F_{n} \quad <Audio> \quad ... \quad </Audio> \]

\[ F_{n+1} \quad <Audio> \quad ... \quad </Audio> \]

The future of the Internet  Bled, March 31 - April 2 2008 14
Music Identification

- Audio query
- Feature extraction
- Locality Sensitive Hashing
- Candidate songs
- HMM-based recognition
- Retrieved songs

Robust to:
- tempo changes
- instrumentation
- noise
The future of multimedia searching

- **Going beyond** what the most popular search engines are still doing, that is, searching using text tags associated with multimedia files
- **Using new ways** to analyze, index, and retrieve the tremendous amounts of speech, image, video, and music that are filling the internet
- Need of **efficient index structures** to cope with the scalability problem: P2P is an answer?
Search models

- Scalability
- Determinism

- Centralized
- Parallel
- Distributed
- Peer-to-peer
- Self-organized

- Well established
- Cutting-edge
- Research
Search models

- 10^{10} pages
- 10^6 computers
- Google File System

- 10^8 images
- 10^3 peers
- Metric technology

Scalability

Determinism
Technological requirements for Multimedia Search Engines

- **Media specific analysis and feature extraction**: e.g. Music Information Retrieval
- **Scalable, dynamic and distributed index structures** supporting similarity search
- **Complex/multi-feature** query processing: combining evidence from different media indexes, using the similarity paradigm
- **Support of distributed push-based crawling**, where containers are asked to publish and “push” information to the search engine (together with the traditional pull-based crawling)
- **Scalable dynamic caching techniques** to enhance performance
- **Context based support** (based on user location, activity, etc.)
New indexing techniques for P2P: M-CAN

• Range query $R(q, r)$
  – map the $q$ on $F(q)$
  – route the query towards $F(q)$
• Reach regions with candidate objects
  – $L_\infty(F(x), F(q)) \leq r$
• Propagate the query over the candidate regions
  – using a multicast algorithm of CAN
• Check objects using $d$
P2P Solutions for A/V Search

P2P-based solution will be able to solve the fundamental **Scalability Issue**, concerning not only:

- *Distributed Similarity Search structures*

but also:

- **Cooperative A/V features extraction**
- **Support of highly dynamic applications** (e.g. videoblogs, photoblogs, etc.)
- **Push-based/cooperative crawling**
Requirements on the network infrastructure

• Fast message switching for P2P index searching
• P2P based efficient streaming (video, music, etc.) to support interactive browsing
• Real-time response needed for special search applications (e.g. to make "context-based" decision: you drive on a highway and you need to decide where to exit, issuing a combined query).
Multimedia Search Engines of the future based on P2P architectures

A new opportunity for Europe?