כריית מידע
(Data Mining (DM

מרצה: ד"ר מרק לסט
מרכזת הקורס: ד"ר מיה הרמן

יחידה 15: נושאים מתקדמים

תיאור היחידה

כריית טקסט, כריית תוכן באינטרנט, כריית מולטימדיה.

Lesson 15 – Advanced Topics

- Text Mining
- Web Mining
- Mining Multimedia Data

Text Mining Definition

- Feldman and Sanger, 2007:
  - **Text mining** can be broadly defined as a knowledge-intensive process in which a user interacts with a document collection over time by using a suite of analysis tools

Slide by Ronen Feldman, BIU

What Is Unique in Text Mining?

- Feature extraction.
- Very large number of features that represent each of the documents.
- The need for background knowledge.
- Even patterns supported by small number of document may be significant.
- Huge number of patterns, hence need for visualization, interactive exploration.

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Text Mining

Input

Documents

Output

Patterns

Connections

Profiles

Trends

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Document Types

- Structured documents
  - Output from CGI (Common Gateway Interface)
- Semi-structured documents
  - Seminar announcements
  - Job listings
  - Ads
- Free format documents
  - News
  - Scientific papers

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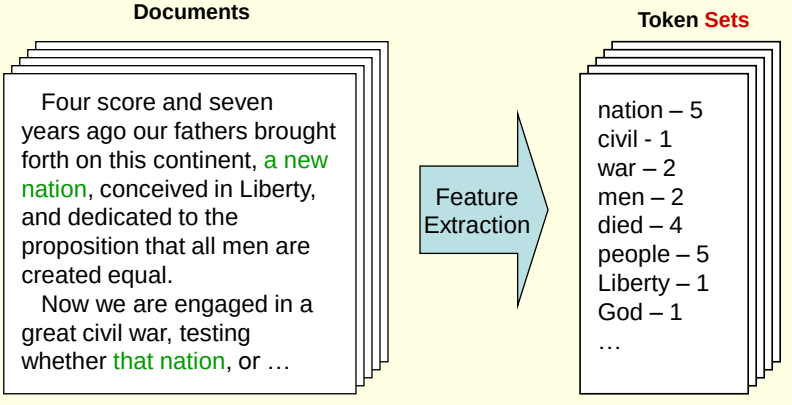
Text Representations

- Characters
- *n*-grams
- Words
- Linguistic Phrases
- Keyphrases
- Non-consecutive phrases
- Concepts
- Frames
- Parse trees
- Graphs

Bag-of-Words Approach



Loses all order-specific information!
Severely limits context!

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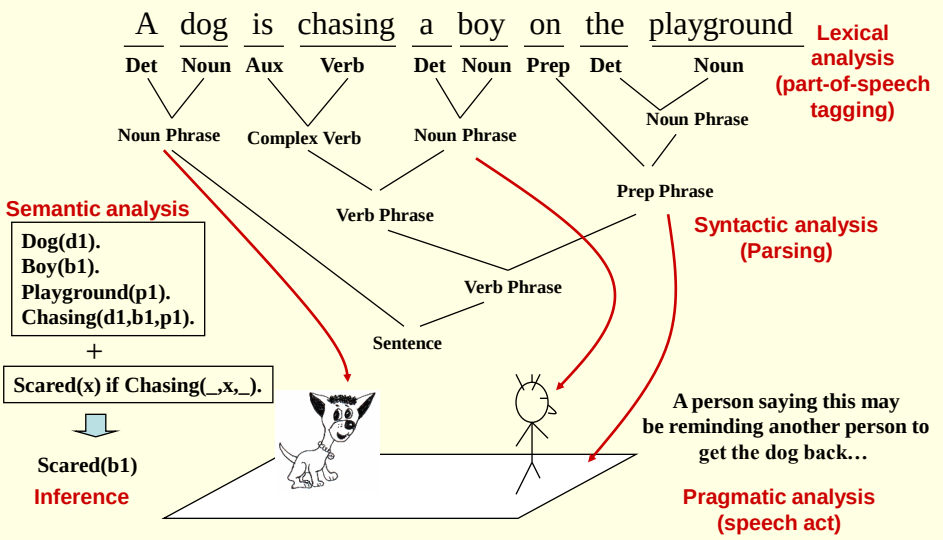
Natural Language Processing



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(Taken from ChengXiang Zhai, CS 397cxz – Fall 2003)

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General NLP—Too Difficult!

- Word-level ambiguity
  - **"design" can be a noun or a verb** (Ambiguous POS)
  - **"root" has multiple meanings** (Ambiguous sense)
- Syntactic ambiguity
  - **"natural language processing"** (Modification)
  - **"A man saw a boy *with a telescope*."** (PP Attachment)
- Anaphora resolution
  - **"John persuaded Bill to buy a TV for *himself*."**
    (*himself* = John or Bill?)
- Presupposition
  - **"He has quit smoking." implies that he smoked before.**

Humans rely on context to interpret (when possible).
This context may extend beyond a given document!

(Taken from ChengXiang Zhai, CS 397cxz – Fall 2003) יחידה 15

Shallow Linguistics

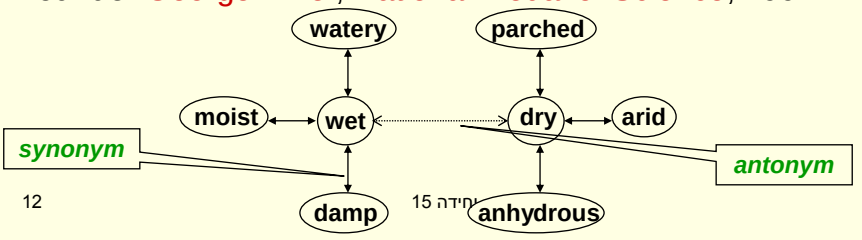
Progress on Useful Sub-Goals:

- English Lexicon
- Part-of-Speech Tagging
- Word Sense Disambiguation
- Phrase Detection / Parsing

WordNet

An extensive lexical network for the English language

- Contains over 138,838 words.
- Several graphs, one for each part-of-speech.
- *Synsets* (synonym sets), each defining a semantic sense.
- Relationship information (antonym, hyponym, meronym …)
- Downloadable for free (UNIX, Windows)
- Expanding to other languages (Global WordNet Association)
- Funded >$3 million, mainly government (translation interest)
- Founder George Miller, National Medal of Science, 1991.



Text Mining Technologies
(based on CACM, Sept. 2006)

- Information extraction
  - Identifying key phrases and relationships within text
- Topic tracking
  - A topic-tracking system keeps user profiles and, based on the documents a user views, predicts other documents of interest to the user.
- Summarization.
  - Text summarization helps users figure out whether a lengthy document meets their needs and is worth reading.

Text Mining Technologies (cont.)

- Categorization
  - Categorization involves identifying the main themes of a document
- Clustering
  - Clustering is a technique used to group similar documents, but it differs from categorization in that documents are clustered on the fly instead of through predefined topics.
- Concept linkage
  - Concept-linkage tools connect related documents by identifying their shared concepts, helping users find information they perhaps wouldn't have found through traditional search methods.

Information Extraction (IE)

- IE does not indicate which documents need to be read by a user, it rather extracts pieces of information that are salient to the user's needs.
- Links between the extracted information and the original documents are maintained to allow the user to reference context.
- The kinds of information that systems extract vary in detail and reliability.
- Named entities such as persons and organizations can be extracted with reliability in the 90th percentile range, but do not provide attributes, facts, or events that those entities have or participate in.

IE Accuracy by Information Type

Information Type	Accuracy
Entities	90-98%
Attributes	80%
Facts	70%
Events	60%

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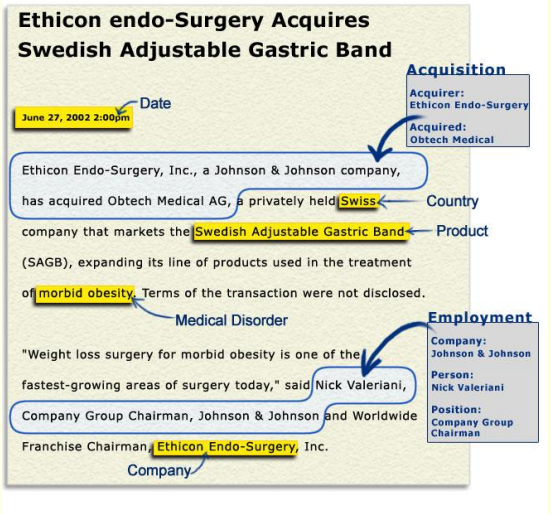
IE Example 1: A Tagged News Document



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IE Example 2: A Merger Article

Text Categorization (TC)

Basic Definition

- TC – task of assigning a Boolean {T, F} value to each pair $\langle d_j, c_i \rangle \in D \times C$

where
$D = (d_1, \ldots, d_{|D|})$ is a collection of documents
$C = (c_1, \ldots, c_{|C|})$ is a set of pre-defined categories

–Sample categories: "sports", "entertainment", "finance", etc.

Inductive text classification / categorization

- The Goal
  - Infer a classification model from a representative sample of labeled training documents
- Requirements in the Web Domain
  - High accuracy
    - The correct category/ categories of each document should be identified as accurately as possible
  - Interpretability
    - An automatically induced model should be subject to scrutiny by a human expert
  - Speed
    - The model should be capable to process massive streams of web documents in minimal time
  - Multilinguality
    - The model induction methods should maintain a high performance level over web content in multiple languages

Text Categorization (TC) Tasks

- Binary TC – two non-overlapping categories only
  - Example: “academic” vs. “non-academic”
- Multi-Class TC – more than two non-overlapping categories
  - Example: “sports” or “politics” or “computing”
  - A multi-class problem can be reduced into multiple binary tasks (*one-against-the-rest* strategy)
- Multi-Label TC – overlapping categories are allowed
  - Example: an “academic” document on “computing”
  - A multi-label task can be split into a set of binary classification tasks
- Ranking categorization
  - *Category ranking*: which categories match a given document best?
  - *Document ranking*: which documents match a given category best?

Document Clustering

- Motivation
  - Automatically group related documents based on their contents
  - No predetermined training sets or taxonomies
  - Generate a taxonomy at runtime
- Clustering Process
  - Data preprocessing: remove stop words, stem, feature extraction, lexical analysis, etc.
  - Hierarchical clustering: compute similarities applying clustering algorithms.
  - Model-Based clustering (Neural Network Approach): clusters are represented by “exemplars”. (e.g.: SOM)

Lesson 15 – Advanced Topics

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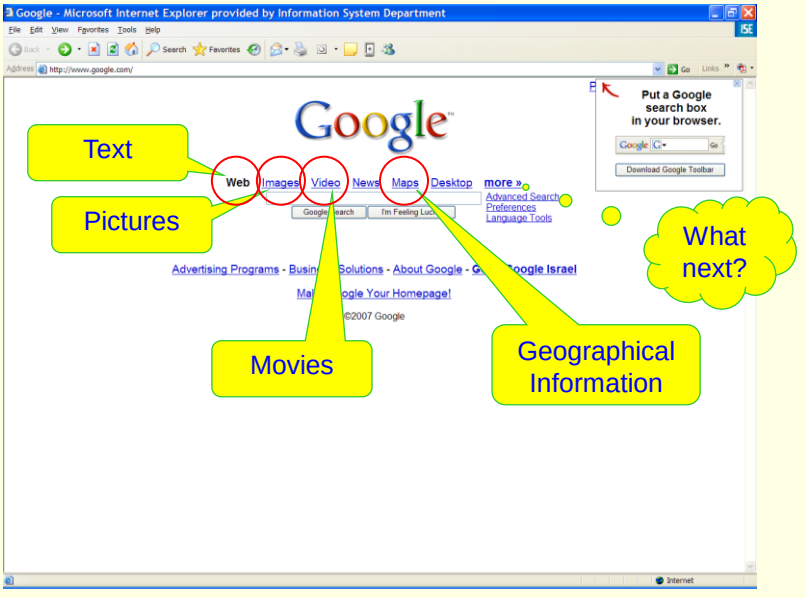
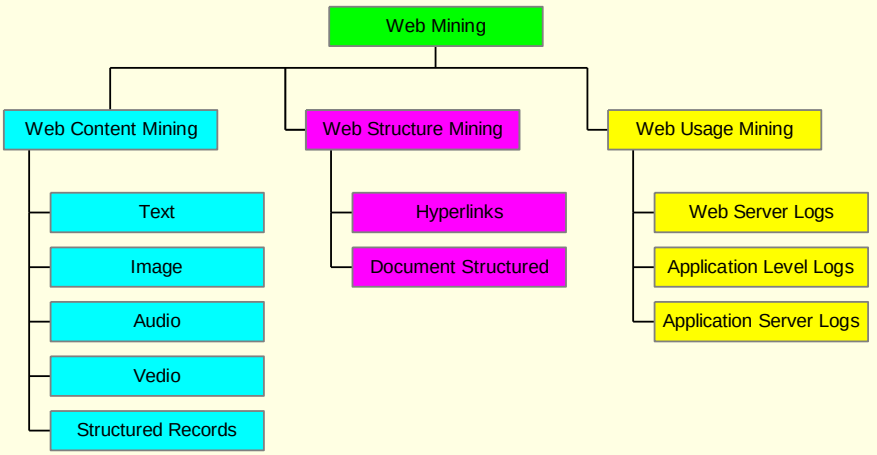
- Web Mining
- Mining Multimedia Data



Web Mining Tasks

- Web mining - the application of data mining techniques to extract knowledge from Web content, structure, and usage.



Web Content Mining: Definition

- "Web Content Mining is the process of extracting useful information from the contents of Web documents. It may consist of text, images, audio, video, or structured records such as lists and tables."
- "Web Content mining refers to the overall process of discovering potentially useful and previously unknown information or knowledge from the Web data."

Source: Bing Liu, UIC

The Web: Opportunities & Challenges

- Web offers an unprecedented opportunity and challenge to data mining
  - The amount of information on the Web is huge and easily accessible.
  - The coverage of Web information is very wide and diverse. One can find information about almost anything.
  - Information/data of almost all types exist on the Web, e.g., structured tables, texts, multimedia data, etc.

Source: Bing Liu, UIC

More Opportunities & Challenges

- Much of the Web information is semi-structured due to the nested structure of HTML code.
- Much of the Web information is linked. There are hyperlinks among pages within a site, and across different sites.
- Much of the Web information is redundant. The same piece of information or its variants may appear in many pages.
- The Web is noisy. A Web page typically contains a mixture of many kinds of information, e.g., main contents, advertisements, navigation panels, copyright notices, etc.

Source: Bing Liu, UIC

Even More Opportunities & Challenges

- The Web consists of surface Web and deep Web.
  - Surface Web: pages that can be browsed using a browser.
  - Deep Web: databases that can only be accessed through parameterized query interfaces.
- The Web is also about services. Many Web sites and pages enable people to perform operations with input parameters, i.e., they provide services.
- The Web is dynamic. Information on the Web changes constantly. Keeping up with the changes and monitoring the changes are important issues.
- Above all, the Web is a virtual society. It is not only about data, information and services, but also about interactions among people, organizations and automatic systems, i.e., communities.

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Similarity Search in Multimedia Data

- Description-based retrieval systems
  - Build indices and perform object retrieval based on image descriptions, such as keywords, captions, size, and time of creation
  - Labor-intensive if performed manually
  - Results are typically of poor quality if automated
- Content-based retrieval systems
  - Support retrieval based on the image content, such as color histogram, texture, shape, objects, and wavelet transforms

Approaches Based on Image Signature

- Color histogram-based signature
  - The signature includes color histograms based on color composition of an image regardless of its scale or orientation
  - No information about shape, location, or texture
  - Two images with similar color composition may contain very different shapes or textures, and thus could be completely unrelated in semantics
- Multifeature composed signature
  - Define different distance functions for color, shape, location, and texture, and subsequently combine them to derive the overall result

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Mining Multimedia Databases

Refining or combining searches

Search for “blue sky”
(top layout grid is blue)

Search for “airplane in blue sky”
(top layout grid is blue and keyword = “airplane”)

Search for “blue sky and green meadows”
(top layout grid is blue and bottom is green)

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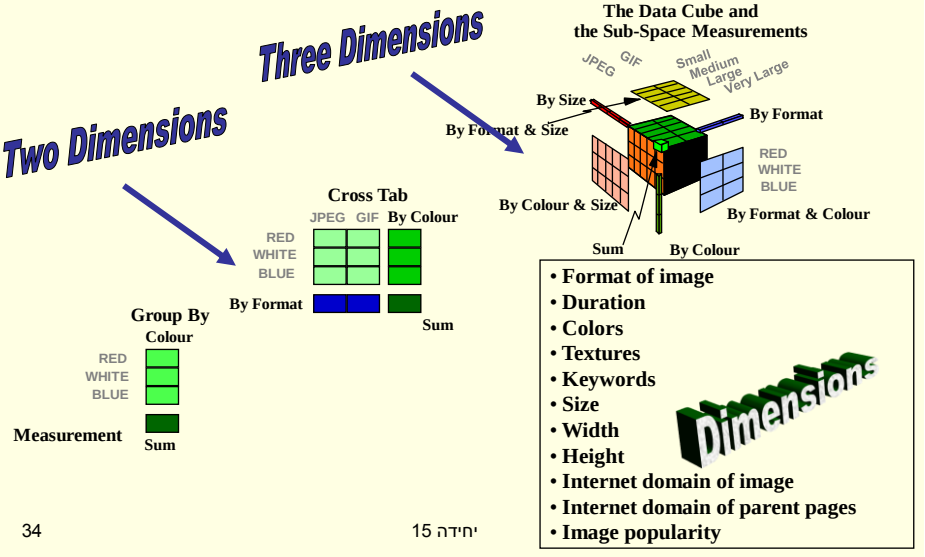
Mining Multimedia Databases



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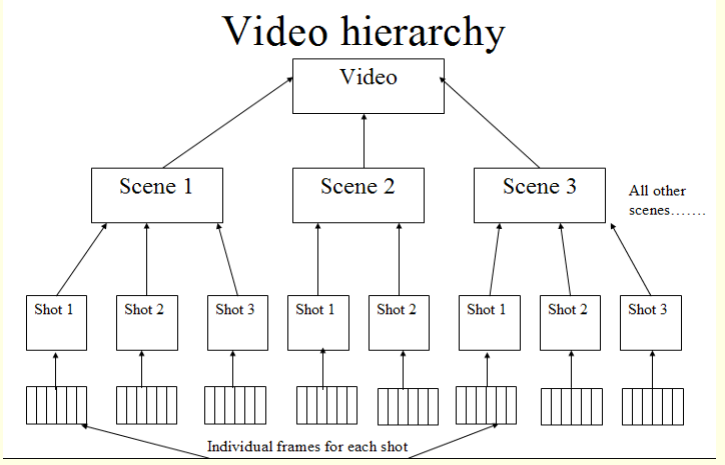
Video Segmentation

Videos sequences can be segmented in a hierarchical fashion into **scenes** (specific story sequence), **shots** (single camera sequence), and **frames** (individual images extracted from each shot).



Object-Based Video Segmentation

- Each frame in a given video sequence (i.e., shot) is segmented into objects based on a pre-specified criteria (such as color, texture, motion, etc.)

Frame 90

Frame 90 Segmented Regions

Object Based Video Segmentation (cont.)

- All objects are maintained (foreground/background) for the entire sequence
- Corresponding objects are matched and assigned same labels
- Valuable when implementing
  - MPEG-4 Video Compression
  - MPEG-7 Video Retrieval
  - Video Databases and Video Data Mining Applications

Video Mining – Challenges and Research Directions

- Video clustering and categorization
- Video based object recognition
- Video segmentation and summarization
- Video feature extraction and representation
- Video indexing and retrieval
- Video search engines
- Video editing and browsing systems
- Visual event and activity detection

- Statistical techniques for video analysis
- Semantic video content analysis
- Video processing for HCI
- Video surveillance (person identification, abnormal activity labeling …)
- Consumer video applications (sports highlight detection, commercial message extraction …)

Summary

- The feature extraction stage in text mining is the most challenging and labor intensive
- Text mining tasks include information extraction, document categorization, document clustering, and many others
- Web mining is the application of data mining techniques to extract knowledge from Web content, structure, and usage
- Mining multimedia, especially video data is an emerging and still under-explored field