Web Mining – Data Mining im Internet

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General Information

- Web-page:
  - http://www.ke.informatik.tu-darmstadt.de/lehre/ss06/web-mining/
- Text:
  - Soumen Chakrabarti: *Mining the Web – Discovering Knowlege from Hypertext Data*, Morgan Kaufmann Publishers 2003.
  - Johannes Fürnkranz: *Web Mining.* Draft book chapter with many pointers to the literature
  - Various other articles available from the Web-page
- Slides:
  - available from course page

Motivation

- The Web is now over 10 years old
  - ca. 1990, Tim Berners-Lee, CERN developed the first graphical hypertext browser
- The information on the Web has grown exponentially
  - on probably every topic you can think of, there is some information available on some Web page
- However, it is still very hard to find relevant information
  - The query interface to search engines has not changed since the early days of the Web!
    - Users have adapted to the interface instead of the other way around

Google

Web Bilder Groups Verzeichnis News Froogle Neu! Desktop

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Extract data from target websites
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Hard queries

- For many queries, the information that is needed to answer the query is readily available on the Web:
  - What are the cheapest hotels in Vienna's first district?
- The problems are
  - finding the pages that contain relevant information
    - pages of hotels in Vienna
  - extracting the relevant pieces of information from these pages
    - finding the prices, names, address of these hotels
  - connecting the information that is extracted from the pages
    - comparing the prices, sorting the hotels
  - apply common-sense reasoning in all phases
    - e.g., look for pages of bed & breakfast (Pension) as well
    - know about different currencies and conversions, etc.

Example Application: Citeseer

- Citeseer is a very popular search engine for publications in Computer Science
  - http://citeseer.ist.psu.edu/
- It provides
  - keyword search for articles
  - on-line access to the articles
  - pointers to articles that the articles cites
  - pointers to articles that cite an article
  - pointers to related articles
  - identification of important papers (citation analysis)
  - identification of important publication media
- All of that is generated automatically!

Searching for **PHRASE web mining**.
Restrict to: Author Title Order by: Expected citations Date Hits: 100 Try: Google (CiteSeer) Google (Web) Yahoo! MSN CSB DBLP
596 citations found. Retrieving citations...

Context Doc ***52*** *(9)*: Robert Cooley, Bamshad Mobasher, and Jaideep Srivastava. ***Web mining****: Information and pattern discovery on the world wide web.* In ICTAI'97, Dec. 1997.

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Context Doc ***34*** *(1)*: B. Mobasher, N. Jain, E-H. Han, and J. Srivastava "***Web mining****: Pattern discovery from world wide* ***web*** *transactions*, " Technical Report 96-050, University of Minnesota, Sep, 1996.

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Web Mining: Information and Pattern Discovery on the World Wide Web *

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Abstract

Application of data mining techniques to the World Wide Web, referred to as Web mining, has been the focus of several recent research projects and papers. However, there is no established vocabulary, leading to confusion when comparing research efforts. The term Web mining has been used in two distinct ways. The first, called Web content mining in this paper, is the process of information discovery from sources across the World Wide Web. The second, called Web usage mining, is the process of mining for user browsing and access patterns. In this paper we define Web mining and present an overview of the various research issues, techniques, and development efforts. We briefly describe WEBMINER, a system for Web usage mining, and conclude this paper by listing research issues.

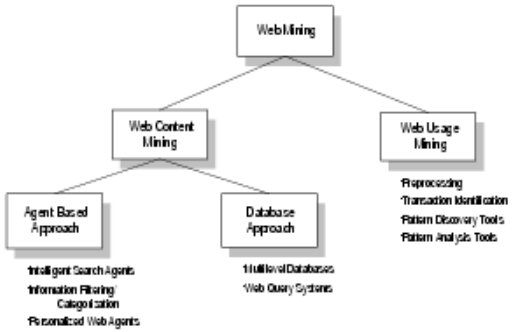

Figure 1: Taxonomy of Web Mining

1 Introduction

With the explosive growth of information sources available on the World Wide Web, it has become increasingly necessary for users to utilize automated tools in find the desired information resources, and to track and analyze their usage patterns. These factors

context. There are several important issues, unique to the Web paradigm, that come into play if sophisticated types of analyses are to be done on server side data collections. These include integrating various data sources such as server access logs, referrer logs, user registration or profile information; resolving difficulties in the identification of users due to missing unique key attributes in collected data; and the importance of identifying user sessions or transactions

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be viewed as a special case of the m
can be said to have three operations

Low-Complexity Fuzzy Relational Clustering Algorithms for Web Mining

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Task that need to be solved

- Information Retrieval
  - search for research papers on the Web
- Information Extraction
  - extract relevant information (title, author, journal/conference, publication year,...) from the research papers
  - extract citations from the research papers
- Information Integration
  - match extracted citations with the text where they are cited
  - match extracted citations with other extracted citations
  - identify similar documents
- Citation analysis
  - build and analyze a graph of citations of papers
  - build and analyze a co-authorship graph
- and many more...

Web Mining

Web Mining is Data Mining for Data on the World-Wide Web

- Text Mining:
  - Application of Data Mining techniques to unstructured (free-format) text
- Structure Mining:
  - taking into account the structure of (semi-)structured hypertext (HTML tags, hyperlinks)
- Usage Mining:
  - taking into account user interactions with the text data (click-streams, collaborative filtering, ...)

Web Mining Tasks

- Message Filter or Message Sorter
- Intelligent Browsing Assistants
- Formation or Update of Web Catalogues
- Ranking or Clustering of Search Results
- Building the Semantic Web / World-Wide Knowledge Base
- Click-stream Analysis
- Product Recommendations
- Digital libraries and Citation Analysis
- ...

The Web

- The Web is a unique kind of hypertext document
  - a large number of pages
  - on a wide variety of topics
  - originating by a large variety of authors
  - speaking many different languages
  - annotated via hyperlinks
  - accessible to everybody
- Main Problem:
  - How can I find the information I am looking for?
- Web Mining:
  - finding and extracting relevant information from the Web

A Brief History of Hypertext

- On Paper
  - Annotated books (e.g., the Talmud)
  - Dictionaries and encyclopedias
    - cross-references are hyperlinks
  - Scientific literature
    - citations of other works is another form of hyperlinks
- Electronic
  - Memex (Vannevar Bush, 1945)
    - design for a photo-eletrical, mechanical storage device that could link documents
    - On-line Demo http://www.dynamicdiagrams.com/demos/memex1a.zip

  - Xanadu (Engelbart & Nelson 1965) http://xanadu.com/
    - first conventional hypertext system, also pioneered wikis
    - too complex to be realized, first use of word „hypertext“
  - Many successor systems

A Brief History of the Web

- Tim Berners-Lee (CERN)
  - first proposals around 1980
  - 1990: work on the „World Wide Web“
  - first graphical interfaces
- 1993:
  - Mosaic (Mark Andressen, NCSA): intuitive hypertext GUI for UNIX
  - HTML: hypertext markup language
  - HTTP: hypertext transport protocol
- 1994:
  - Netscape was founded
  - 1st World Wide Web Conference http://www.w3.org/
  - World Wide Web Consortion founded by CERN and MIT

HTTP (hypertext transport protocol)

- Built on top of the Transport Control Protocol (TCP)
- Steps(from client end) http://www.w3.org/Protocols
  - resolve the server host name to an Internet address (IP)
    - Use Domain Name Server (DNS)
    - DNS is a distributed database of name-to-IP mappings maintained at a set of known servers
  - contact the server using TCP
    - connect to default HTTP port (80) on the server.
    - Enter the HTTP requests header (E.g.: GET)
    - Fetch the response header
      - MIME (Multipurpose Internet Mail Extensions)
      - A meta-data standard for email and Web content transfer
    - Fetch the HTML page

Host Port

```
% telnet www.cse.iitb.ac.in 80
Trying 144.16.111.14...
Connected to www.cse.iitb.ac.in.
Escape character is '^]'.
GET / Http/1.0
```

GET / Http/1.0

Pfad

Header

```
Http/1.1 200 OK
Date: Sat, 13 Jan 2001 09:01:02 GMT
Server: Apache/1.3.0 (Unix) PHP/3.0.4
Last-Modified: Wed, 20 Dec 2000 13:18:38 GMT
ETag: "5c248-153d-3a40b1ae"
Accept-Ranges: bytes
Content-Length: 5437
Connection: close
Content-Type: text/html
X-Pad: avoid browser bug
```

HTML of Web page

```
<html>
<head><title>IIT Bombay CSE Department Home Page</title></head>
<body>...<a href="http://www.iitb.ac.in">IIT Bombay</a>...
</body></html>
Connection closed by foreign host.
```

HTML

http://www.w3.org/MarkUp/

- HyperText Markup Language
- Lets the author
  - specify document structure
    - browser converts structure to layout
    - direct specification of layout and typeface possible
  - embed diagrams
  - create hyperlinks.
    - expressed as an anchor tag with a HREF attribute
    - HREF names another page using a Uniform Resource Locator (URL),
  - URL =
    - protocol field (“HTTP”) +
    - a server hostname (“www.cse.iitb.ac.in”) +
    - file path (/, the `root' of the published file system).

DOM Tree

- DOM = Document Object Model http://www.w3.org/DOM/
- An HTML document can be viewed as a tree
  - markup items are interior nodes
  - text are leafs
  - Xpath: language for denoting the path from the root to a tree
    http://www.zvon.org/xxl/XPathTutorial/General/examples.html
- document structure can be exploited
  - sectioning of documents
  - recognition of important text parts (e.g., anchor text)
  - structural patterns (XPath) may identify important information on the page
- `Firefox->Tools/Web Development/DOM Inspector`

Web: A populist, participatory medium

- number of writers =(approx) number of readers.
- the evolution of MEMES
  - ideas, theories etc that spread from person to person by imitation.
  - good memes survive, bad memes die out
- but the Web archives them all

Abundance and authority crisis

- liberal and informal culture of content generation and dissemination.
  - despite a few commercial niches we still have anarchy
- Very little uniform civil code.
- redundancy and non-standard form and content.
- millions of qualifying pages for most broad queries
  - Example: java or kayaking
- no authoritative information about the reliability of a site

Problems due to Uniform accessibility

- little support for adapting to the background of specific users.
- commercial interests routinely influence the operation of Web search
  - “Search Engine Optimization“ !!

Data Mining - Motivation

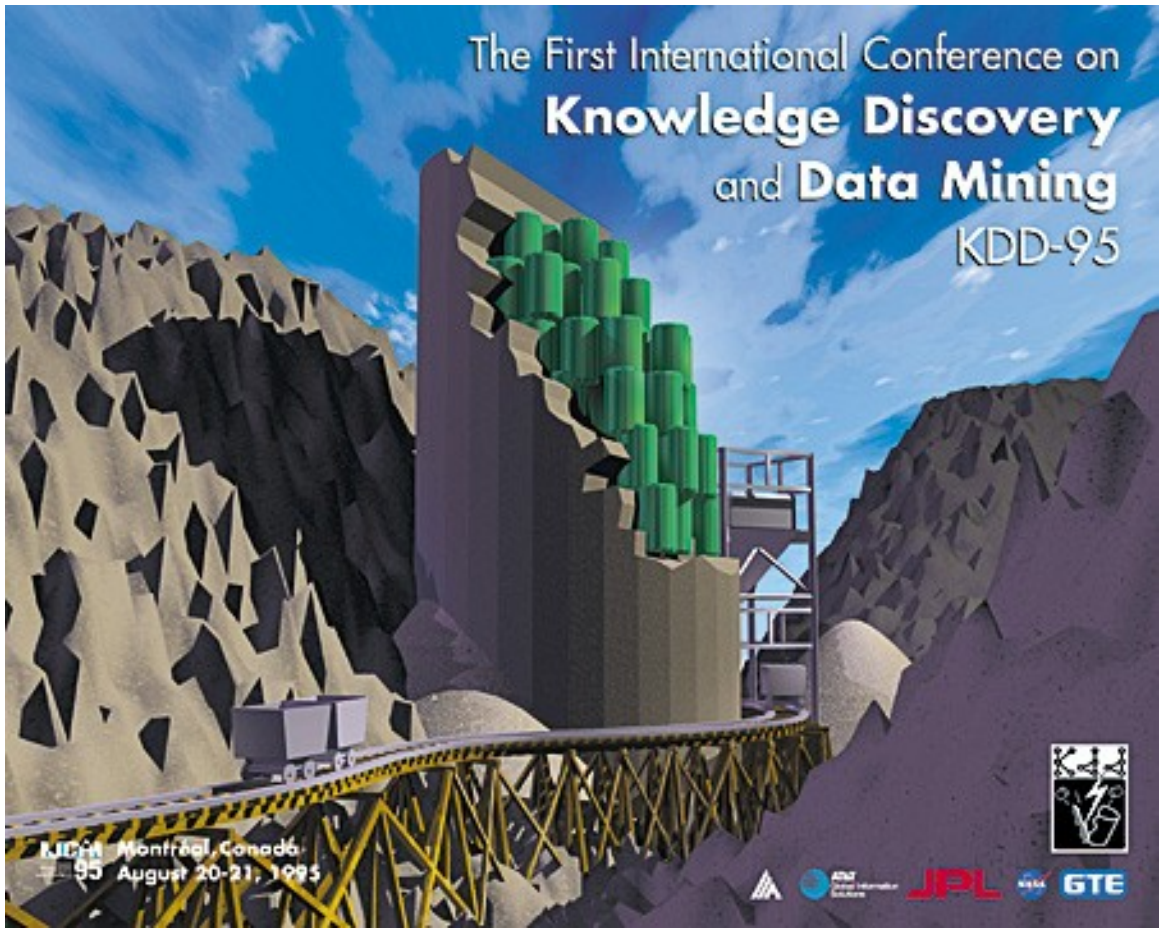
"Computers have promised us a fountain of wisdom but delivered a flood of data."

"It has been estimated that the amount of information in the world doubles every 20 months."

(Frawley, Piatetsky-Shapiro, Matheus, 1992)

Data Mining

Mining for nuggets of knowledge in mountains of Data.



Definition

Data Mining is a non-trivial *process* of identifying

- valid
- novel
- potentially useful
- ultimately understandable

patterns in data.

(Fayyad et al. 1996)

It employs techniques from

- machine learning
- statistics
- databases

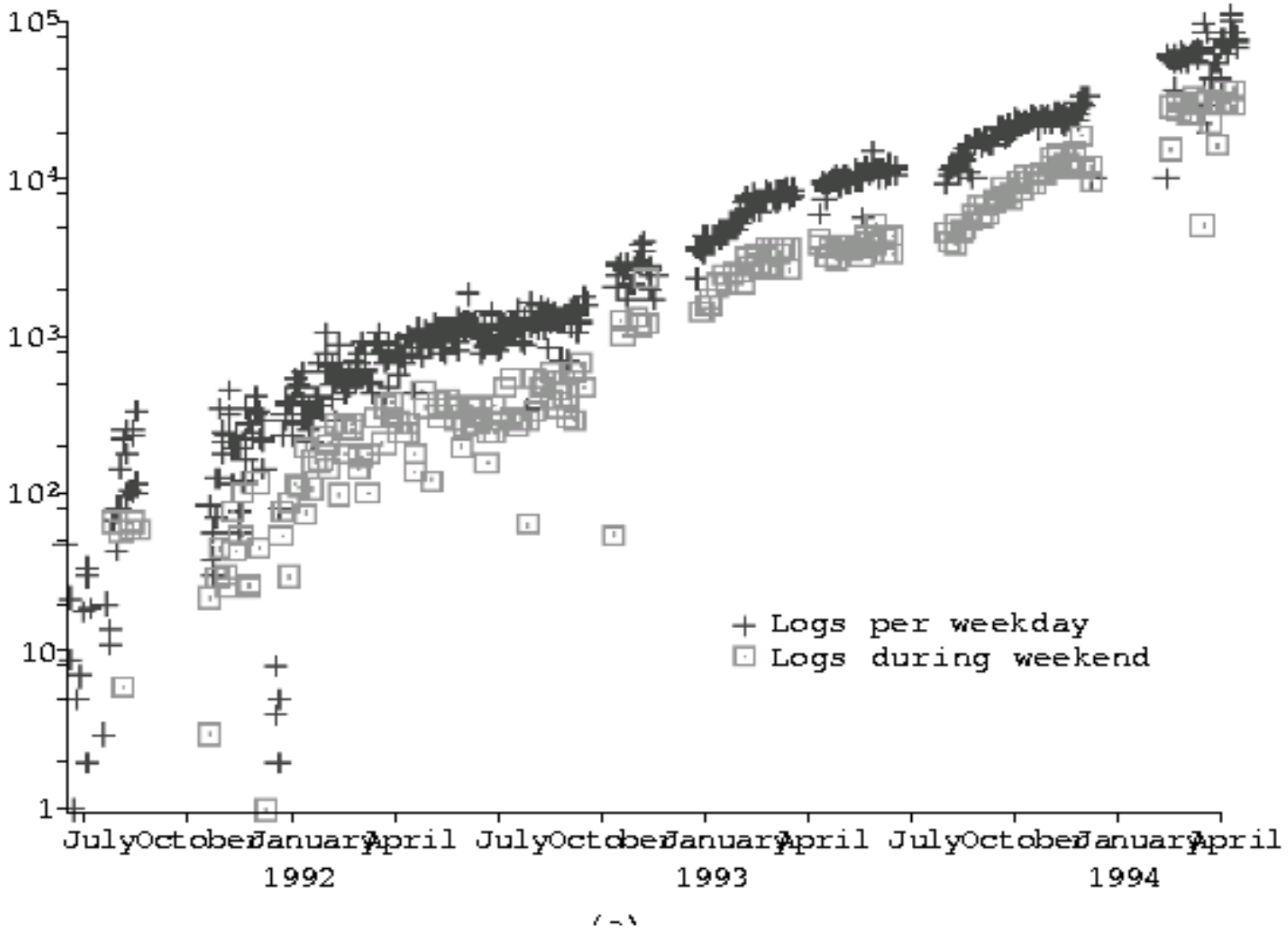
Or maybe:

- Data Mining is torturing your database until it confesses.

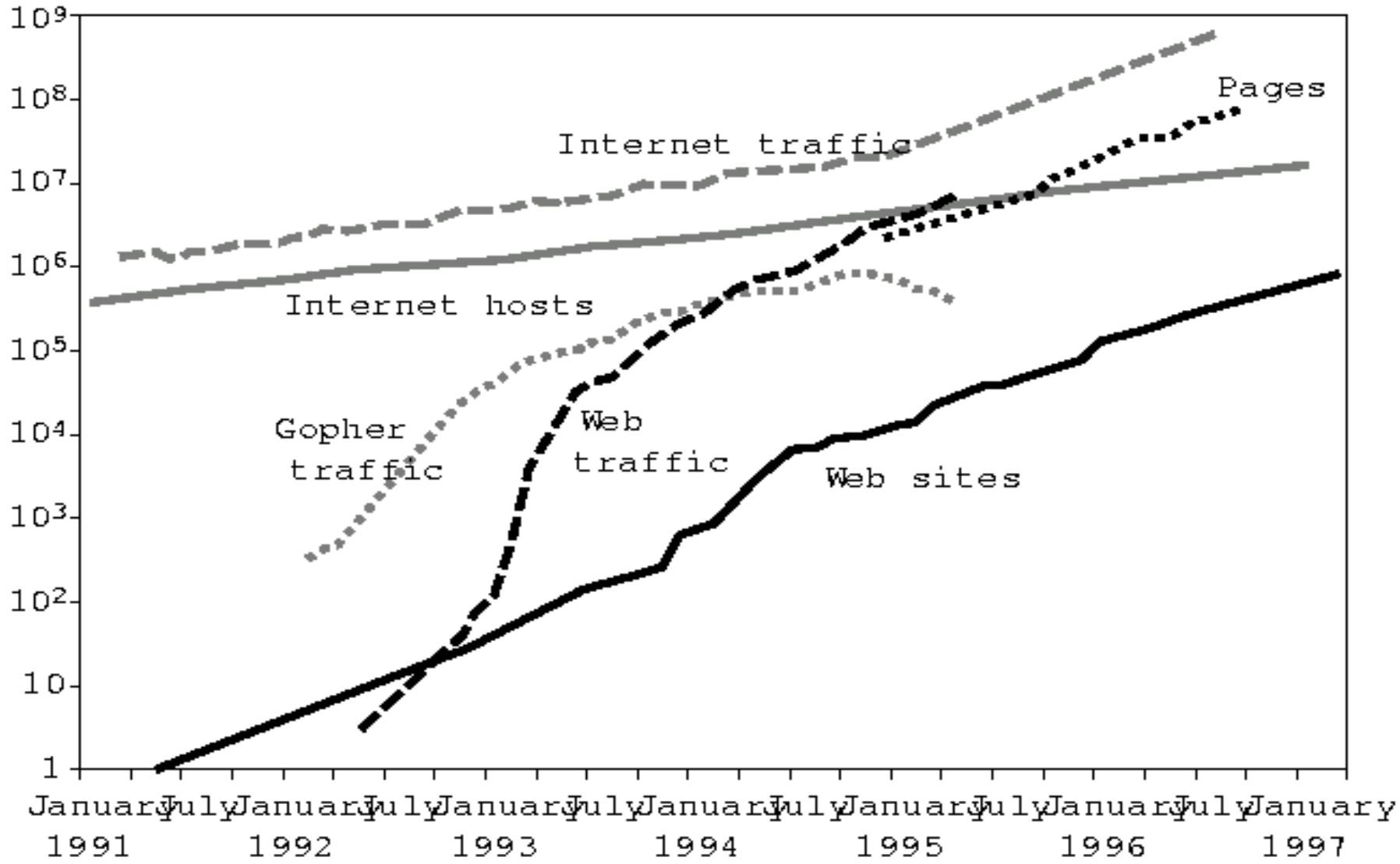
(Mannila (?))

World-Wide Data Growth

- Science
  - satellite monitoring
  - human genome
- Business
  - OLTP (on-line transaction processing)
  - data warehouses
  - e-commerce
- Industry
  - process data
- World-Wide Web



The early days of the Web : CERN HTTP traffic grows by 1000 between 1991–1994 (image courtesy W3C)



The early days of the Web: The number of servers grows from a few hundred to a million between 1991 and 1997 (image courtesy Nielsen)

How Big is the Web?

- Google:
  - early 2001: 1,346,966,000 web pages
  - 11.2.2002: 2,073,418,204
  - 2004: 4,285,199,774
  - 28.4.2005: 8,058,044,651
- Size of the Web
  - Results from 1998 estimate that the best search engines index about 30% of the Web.
- Gulli & Signorini (2005)
  - estimate the size of the Web to 11.5 billion pages,
  - Coverage of search engines
    - Google=76.16%, Msn Beta=61.90%, Ask/Teoma=57.62%, Yahoo!=69.32%

Source: www.thestandard.com

Structured vs. Web data mining

- traditional data mining
  - data is structured and relational
  - well-defined tables, columns, rows, keys, and constraints.
- Web data
  - semi-structured and unstructured
  - readily available
  - rich in features and patterns
  - spontaneous formation and evolution of
    - topic-induced graph clusters
    - hyperlink-induced communities

Structured Data

- Attribute-Value data:
  - Each example is described with values for a fixed number of attributes
    - **Nominal Attributes:**
      - store an unordered list of symbols (e.g., *color*)
    - **Numeric Attributes:**
      - store a number (e.g., *income*)
    - **Other Types:**
      - hierarchical attributes
      - set-valued attributes
  - the data corresponds to a single relation (spreadsheet)
- Multi-Relational data:
  - The relevant information is distributed over multiple relations
  - Inductive Logic Programming

Structured Data

Day	Temperature	Outlook	Humidity	Windy	Play Golf?
07-05	hot	sunny	high	false	no
07-06	hot	sunny	high	true	no
07-07	hot	overcast	high	false	yes
07-09	cool	rain	normal	false	yes
07-10	cool	overcast	normal	true	yes
07-12	mild	sunny	high	false	no
07-14	cool	sunny	normal	false	yes
07-15	mild	rain	normal	false	yes
07-20	mild	sunny	normal	true	yes
07-21	mild	overcast	high	true	yes
07-22	hot	overcast	normal	false	yes
07-23	mild	rain	high	true	no
07-26	cool	rain	normal	true	no
07-30	mild	rain	high	false	yes

today	cool	sunny	normal	false	?
tomorrow	mild	sunny	normal	false	?

Semi-Structured and Unstructured Data

- Semi-structured Data
  - no clear tables
    - it may be hard to identify the attributes for each example
    - it may also be hard to identify the examples themselves
  - some structure implicit in the data
    - e.g., formatting via HTML
  - large parts without structure
    - free text
  - http://weather.yahoo.com/forecast/GMXX0020.html

Semi-Structure
I

- Semi-structured Data
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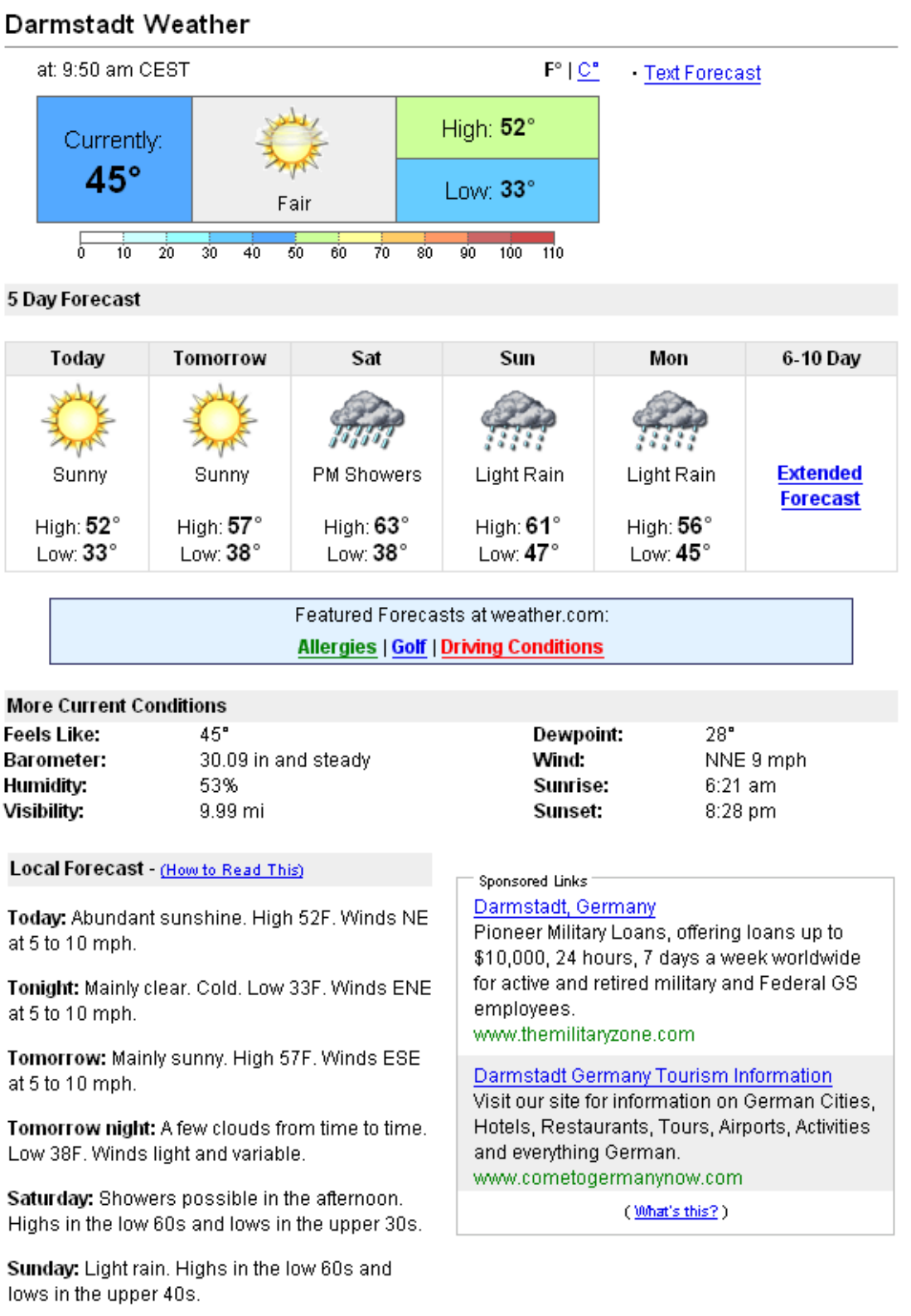

Darmstadt Weather

at: 9:50 am CEST F° | C° · Text Forecast

Currently: 45° Fair High: 52° Low: 33°

0 10 20 30 40 50 60 70 80 90 100 110

5 Day Forecast

Today	Tomorrow	Sat	Sun	Mon	6-10 Day
Sunny	Sunny	PM Showers	Light Rain	Light Rain	Extended Forecast
High: 52° Low: 33°	High: 57° Low: 38°	High: 63° Low: 38°	High: 61° Low: 47°	High: 56° Low: 45°	

Featured Forecasts at weather.com:
Allergies | Golf | Driving Conditions

More Current Conditions

Feels Like:	45°	Dewpoint:	28°
Barometer:	30.09 in and steady	Wind:	NNE 9 mph
Humidity:	53%	Sunrise:	6:21 am
Visibility:	9.99 mi	Sunset:	8:28 pm

Local Forecast - (How to Read This)

Today: Abundant sunshine. High 52F. Winds NE at 5 to 10 mph.

Tonight: Mainly clear. Cold. Low 33F. Winds ENE at 5 to 10 mph.

Tomorrow: Mainly sunny. High 57F. Winds ESE at 5 to 10 mph.

Tomorrow night: A few clouds from time to time. Low 38F. Winds light and variable.

Saturday: Showers possible in the afternoon. Highs in the low 60s and lows in the upper 30s.

Sunday: Light rain. Highs in the low 60s and lows in the upper 40s.

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www.cometogermanynow.com

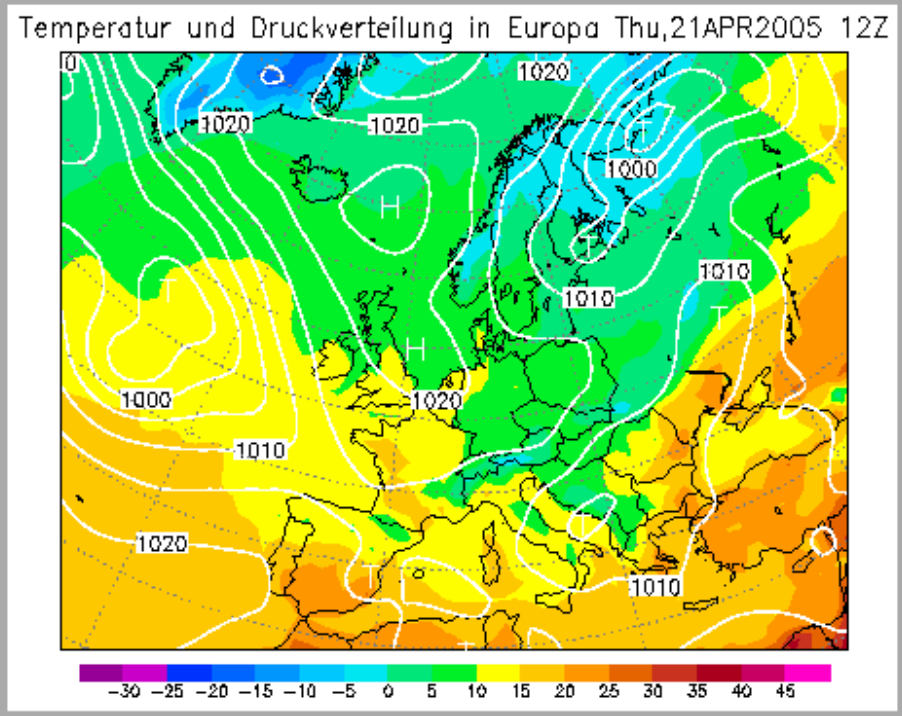
(What's this?)

Semi-Structured and Unstructured Data

- Semi-structured Data
  - no clear tables
    - it may be hard to identify the attributes for each example
    - it may also be hard to identify the examples themselves
  - some structure implicit in the data
    - e.g., formatting via HTML
  - large parts without structure
    - free text
  - http://weather.yahoo.com/forecast/GMXX0020.html
- Unstructured Data
  - free text
  - http://www.wetterzentrale.de/wzwb.html

Der Wetterzentrale Wetterbericht ausgegeben am 21. April 2005, 8:09 MESZ

Lage:
Die aus Nordosten eingeflossene Kaltluft gelangt rasch unter schwachen Hochdruckeinfluss. Bereits am Samstag greifen die Ausläufer westeuropäischer Tiefs auf den Südwesten über und führen mildere und feuchte Luft heran.



Vorhersage für Deutschland:
Heute nach Auflösung örtlichen Nebels meist heiter bis wolkig und trocken. Am Alpenrand anfangs noch stark bewölkt, aber kaum noch Regen. Im Norddeutschen Tiefland ab dem Mittag einige Wolkenfelder. Höchsttemperaturen 8 bis 13 Grad. Dabei am Rhein am mildesten. Schwacher bis mäßiger Wind, im Norden auf West drehend, sonst aus Nordost bis Nord. In der kommenden Nacht im Norden wolkig. Sonst klar. Tiefstwerte zwischen 3 Grad im Norden und bis -3 Grad im Süden.
Morgen östlich der Elbe wolkig, es bleibt aber trocken. Sonst sonnig und trocken. Höchsttemperaturen zwischen 10 Grad an der Oder und bis 16 Grad am Rhein.

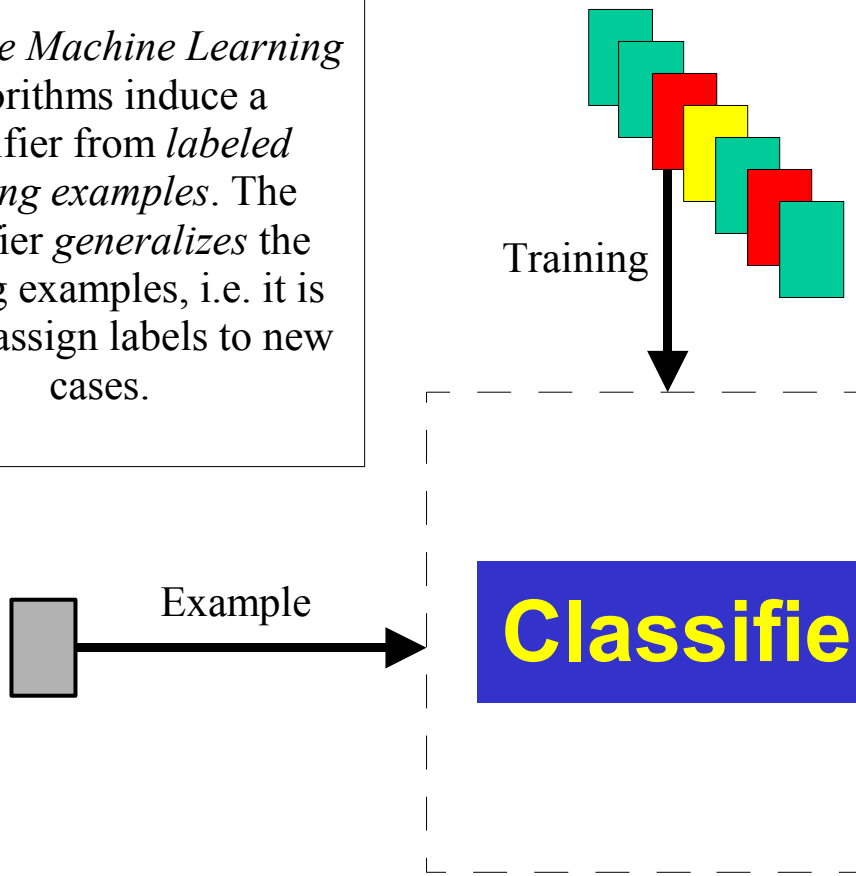
Tendenz für die Folgetage:
Am Samstag im Südwesten bereits am Vormittag zunehmende Bewölkung und ab dem Mittag einsetzender Regen. In der Mitte freundlich und mild. Im Nordosten wolkig und immer noch kühl.
Am Sonntag im Norddeutschen Tiefland heiter bis wolkig und trocken. Bei kräftigem Ostwind recht kühl. In der Mitte und im Süden wolkig bis stark bewölkt mit gebietsweisem Regen oder einzelnen Schauern und mild.
Am Wochenbeginn auch im Norden unbeständiger.
Ab der Wochenmitte deutet sich trockenes und wärmeres Wetter an.

Web Tasks for ML/DM Techniques

- Classifiers:
  - assigning categories to documents (E-mail/newsgroup sorting and filtering, building a Web catalogue, user modelling,...)
- Regression:
  - predict numerical values (ratings, GUI settings,...)
- Clustering:
  - grouping documents (structuring search results, ...)
- Association Rule Discovery:
  - finding events and event sequences that co-occur frequently (click stream analysis,...)
- Reinforcement Learning:
  - learning to improve agents (crawlers, relevance feedback, ...)

Induction of Classifiers

Inductive Machine Learning algorithms induce a classifier from *labeled training examples*. The classifier *generalizes* the training examples, i.e. it is able to assign labels to new cases.



An inductive learning algorithm searches in a given family of hypotheses (e.g., *decision trees, neural networks*) for a member that optimizes given *quality criteria* (e.g., estimated predictive accuracy or misclassification costs).