Business Intelligence Trends
商業智慧趨勢

文字探勘與網路探勘
(Text and Web Mining)

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課程大綱 (Syllabus)

週次	日期	內容（Subject/Topics）
1	102/02/18	商業智慧趨勢課程介紹 (Course Orientation for Business Intelligence Trends)
2	102/02/25	管理決策支援系統與商業智慧 (Management Decision Support System and Business Intelligence)
3	102/03/04	企業績效管理 (Business Performance Management)
4	102/03/11	資料倉儲 (Data Warehousing)
5	102/03/18	商業智慧的資料探勘 (Data Mining for Business Intelligence)
6	102/03/25	商業智慧的資料探勘 (Data Mining for Business Intelligence)
7	102/04/01	教學行政觀摩日 (Off-campus study)
8	102/04/08	個案分析一 (SAS EM 分群分析)： Banking Segmentation (Cluster Analysis – KMeans using SAS EM)
9	102/04/15	個案分析二 (SAS EM 關連分析)： Web Site Usage Associations (Association Analysis using SAS EM)

課程大綱 (Syllabus)

週次	日期	內容（Subject/Topics）
10	102/04/22	期中報告 (Midterm Presentation)
11	102/04/29	個案分析三 (SAS EM 決策樹、模型評估)： Enrollment Management Case Study (Decision Tree, Model Evaluation using SAS EM)
12	102/05/06	個案分析四 (SAS EM 迴歸分析、類神經網路)： Credit Risk Case Study (Regression Analysis, Artificial Neural Network using SAS EM)
13	102/05/13	文字探勘與網路探勘 (Text and Web Mining)
14	102/05/20	意見探勘與情感分析 (Opinion Mining and Sentiment Analysis)
15	102/05/27	商業智慧導入與趨勢 (Business Intelligence Implementation and Trends)
16	102/06/03	商業智慧導入與趨勢 (Business Intelligence Implementation and Trends)
17	102/06/10	期末報告1 (Term Project Presentation 1)
18	102/06/17	期末報告2 (Term Project Presentation 2)

Learning Objectives

- Describe text mining and understand the need for text mining
- Differentiate between text mining, Web mining and data mining
- Understand the different application areas for text mining
- Know the process of carrying out a text mining project
- Understand the different methods to introduce structure to text-based data

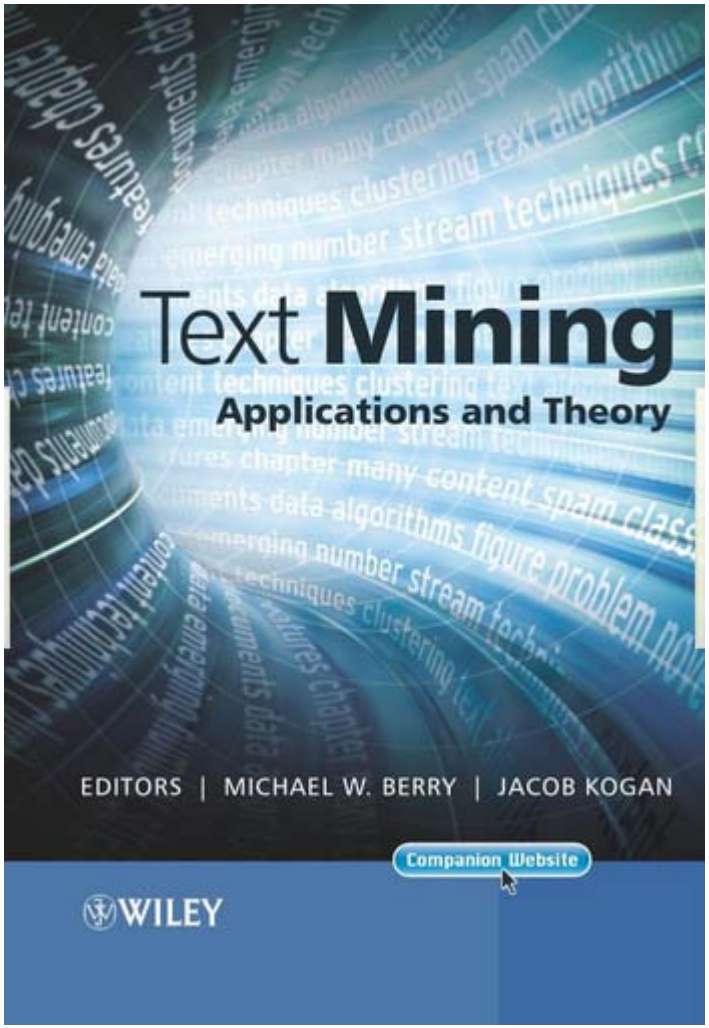
Learning Objectives

- Describe Web mining, its objectives, and its benefits
- Understand the three different branches of Web mining
  - Web content mining
  - Web structure mining
  - Web usage mining
- Understand the applications of these three mining paradigms

Text and Web Mining

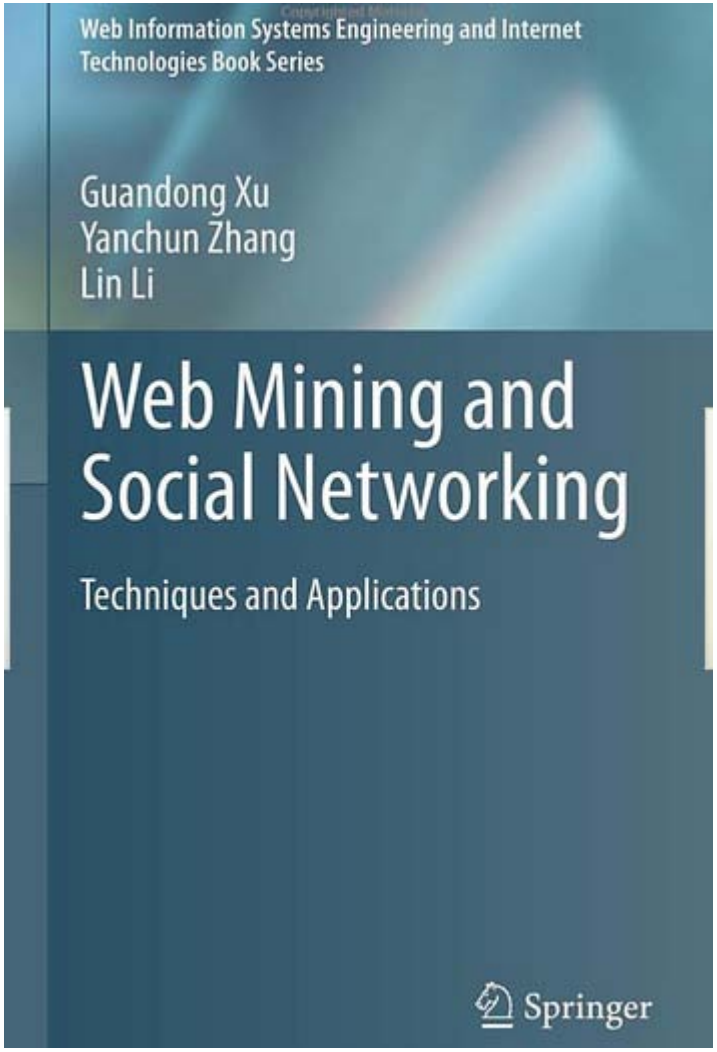
- Text Mining: Applications and Theory
- Web Mining and Social Networking
- Mining the Social Web: Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites
- Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data
- Search Engines – Information Retrieval in Practice

Text Mining



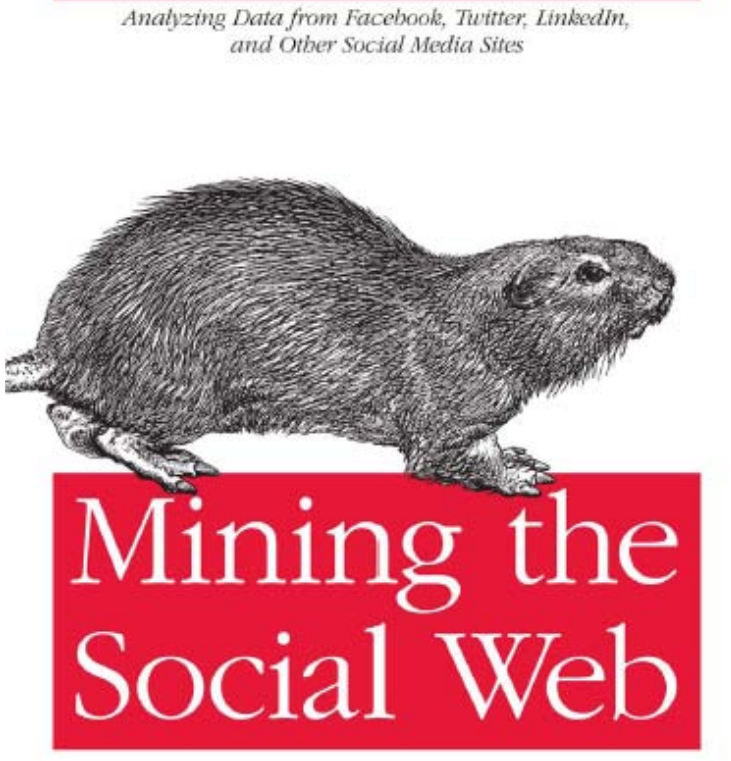
http://www.amazon.com/Text-Mining-Applications-Michael-Berry/dp/0470749822/

Web Mining and Social Networking



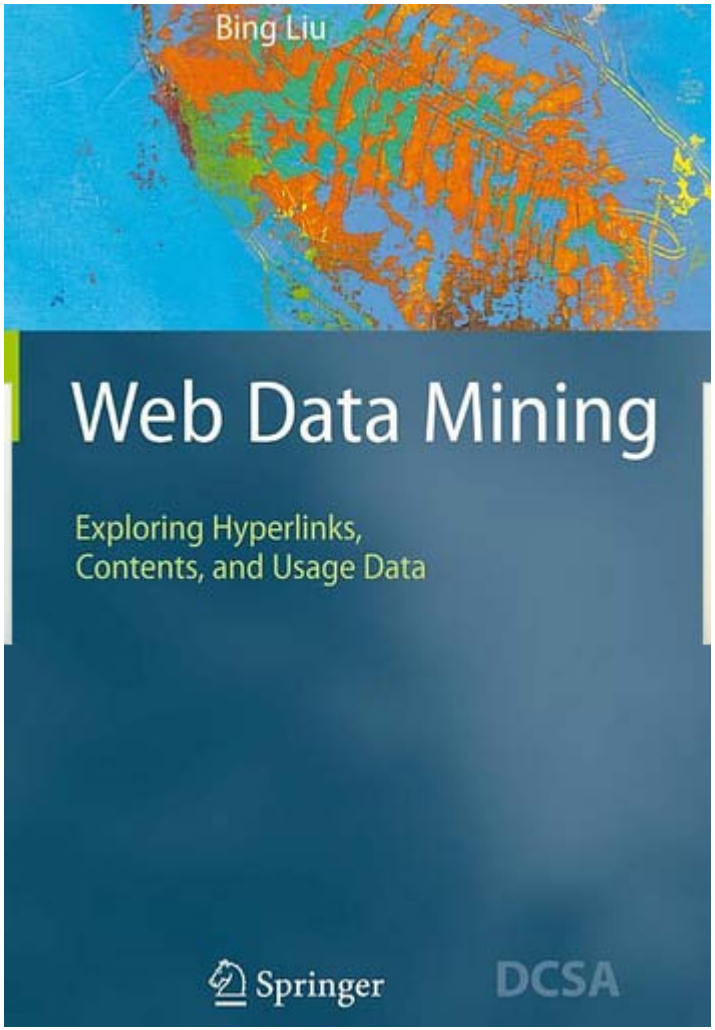
http://www.amazon.com/Web-Mining-Social-Networking-Applications/dp/1441977341

Mining the Social Web: Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites



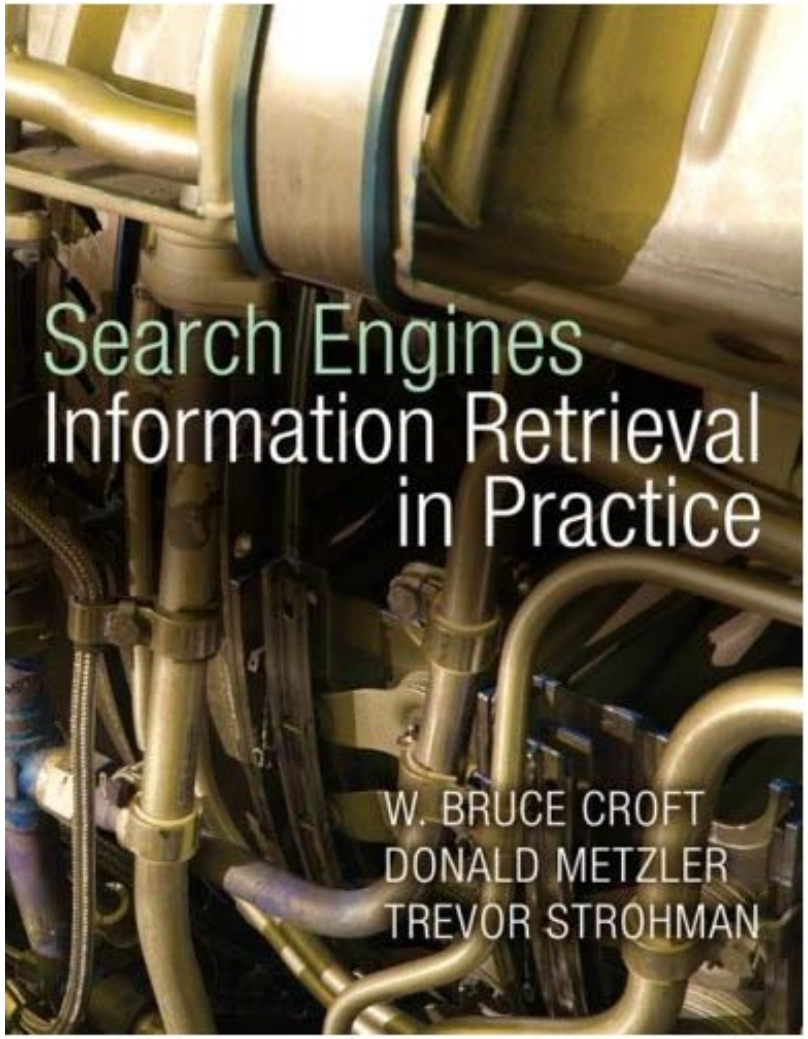
http://www.amazon.com/Mining-Social-Web-Analyzing-Facebook/dp/1449388345

Web Data Mining:
Exploring Hyperlinks, Contents, and Usage Data



http://www.amazon.com/Web-Data-Mining-Data-Centric-Applications/dp/3540378812

Search Engines: Information Retrieval in Practice



http://www.amazon.com/Search-Engines-Information-Retrieval-Practice/dp/0136072240

Text Mining

- Text mining (text data mining)
  - the process of deriving high-quality information from text
- Typical text mining tasks
  - text categorization
  - text clustering
  - concept/entity extraction
  - production of granular taxonomies
  - sentiment analysis
  - document summarization
  - entity relation modeling
    - i.e., learning relations between named entities.

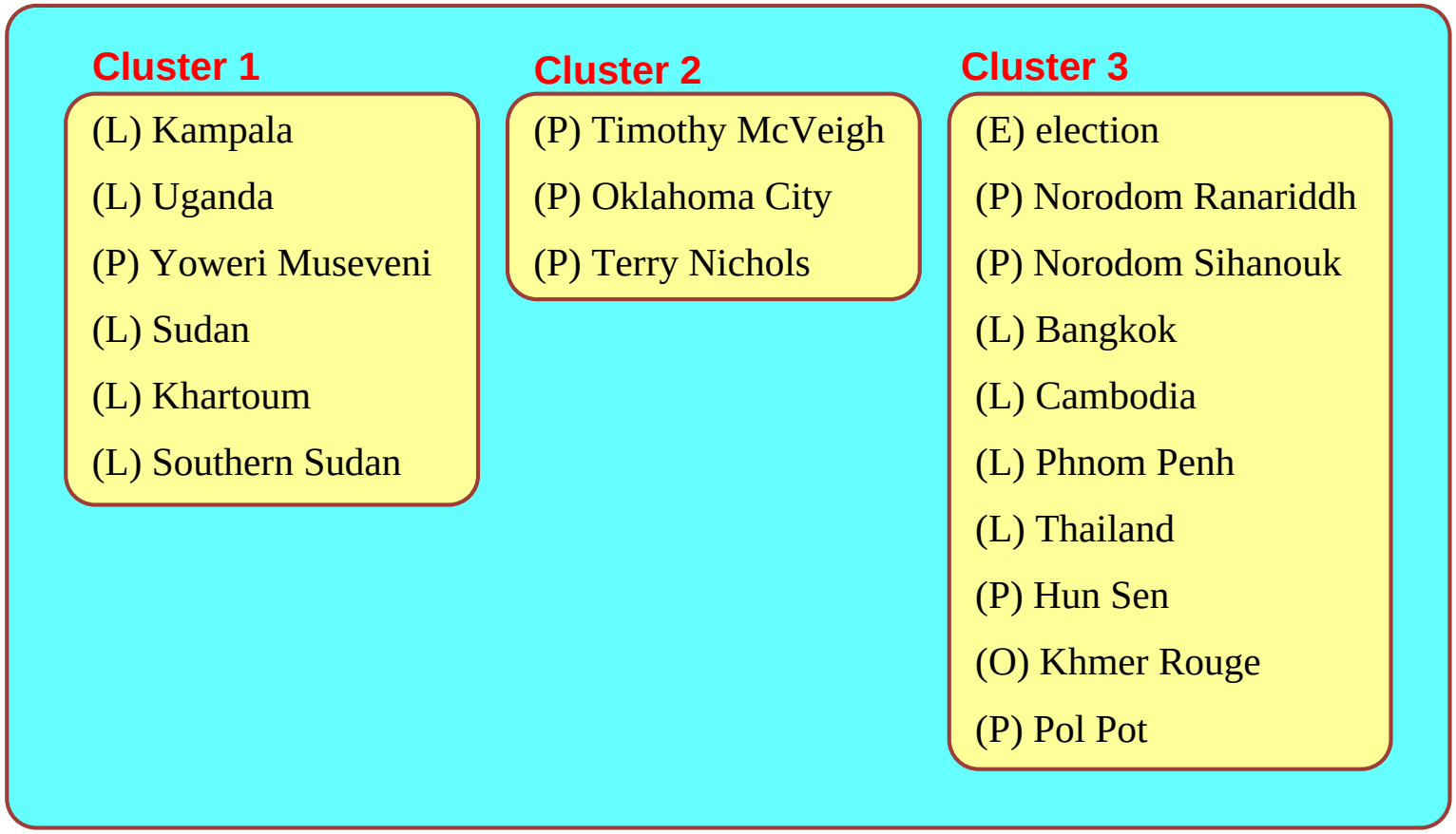
http://en.wikipedia.org/wiki/Text_mining

Web Mining

- Web mining
  - discover useful information or knowledge from the **Web hyperlink structure, page content, and usage data.**
- Three types of web mining tasks
  - Web structure mining
  - Web content mining
  - Web usage mining

Source: Bing Liu (2009) Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data

Mining Text For Security…



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Concepts

- 85-90 percent of all corporate data is in some kind of unstructured form (e.g., text)
- Unstructured corporate data is doubling in size every 18 months
- Tapping into these information sources is not an option, but a need to stay competitive
- Answer: text mining
  - A semi-automated process of extracting knowledge from unstructured data sources
  - a.k.a. text data mining or knowledge discovery in textual databases

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Data Mining versus Text Mining

- Both seek for novel and useful patterns
- Both are semi-automated processes
- Difference is the nature of the data:
  - Structured versus unstructured data
  - Structured data: in databases
  - Unstructured data: Word documents, PDF files, text excerpts, XML files, and so on
- Text mining – first, impose structure to the data, then mine the structured data

Text Mining Concepts

- Benefits of text mining are obvious especially in text-rich data environments
  - e.g., law (court orders), academic research (research articles), finance (quarterly reports), medicine (discharge summaries), biology (molecular interactions), technology (patent files), marketing (customer comments), etc.
- Electronic communization records (e.g., Email)
  - Spam filtering
  - Email prioritization and categorization
  - Automatic response generation

Text Mining Application Area

- Information extraction
- Topic tracking
- Summarization
- Categorization
- Clustering
- Concept linking
- Question answering

Text Mining Terminology

- Unstructured or semistructured data
- Corpus (and corpora)
- Terms
- Concepts
- Stemming
- Stop words (and include words)
- Synonyms (and polysemes)
- Tokenizing

Text Mining Terminology

- Term dictionary
- Word frequency
- Part-of-speech tagging (POS)
- Morphology
- Term-by-document matrix (TDM)
  - Occurrence matrix
- Singular Value Decomposition (SVD)
  - Latent Semantic Indexing (LSI)

Text Mining for Patent Analysis

- What is a patent?
  - "exclusive rights granted by a country to an inventor for a limited period of time in exchange for a disclosure of an invention"
- How do we do patent analysis (PA)?
- Why do we need to do PA?
  - What are the benefits?
  - What are the challenges?
- How does text mining help in PA?

Natural Language Processing (NLP)

- Structuring a collection of text
  - Old approach: bag-of-words
  - New approach: natural language processing
- NLP is …
  - a very important concept in text mining
  - a subfield of artificial intelligence and computational linguistics
  - the studies of "understanding" the natural human language
- Syntax versus semantics based text mining

Natural Language Processing (NLP)

- What is “Understanding” ?
  - Human understands, what about computers?
  - Natural language is vague, context driven
  - True understanding requires extensive knowledge of a topic
  - Can/will computers ever understand natural language the same/accurate way we do?

Natural Language Processing (NLP)

- Challenges in NLP
  - Part-of-speech tagging
  - Text segmentation
  - Word sense disambiguation
  - Syntax ambiguity
  - Imperfect or irregular input
  - Speech acts
- Dream of AI community
  - to have algorithms that are capable of automatically reading and obtaining knowledge from text

Natural Language Processing (NLP)

- WordNet
  - A laboriously hand-coded database of English words, their definitions, sets of synonyms, and various semantic relations between synonym sets
  - A major resource for NLP
  - Need automation to be completed
- Sentiment Analysis
  - A technique used to detect favorable and unfavorable opinions toward specific products and services
  - CRM application

NLP Task Categories

- Information retrieval (IR)
- Information extraction (IE)
- Named-entity recognition (NER)
- Question answering (QA)
- Automatic summarization
- Natural language generation and understanding (NLU)
- Machine translation (ML)
- Foreign language reading and writing
- Speech recognition
- Text proofing
- Optical character recognition (OCR)

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Applications

- Marketing applications
  - Enables better CRM
- Security applications
  - ECHELON, OASIS
  - Deception detection (…)
- Medicine and biology
  - Literature-based gene identification (…)
- Academic applications
  - Research stream analysis

Text Mining Applications

- Application Case: Mining for Lies
- Deception detection
  - A difficult problem
  - If detection is limited to only text, then the problem is even more difficult
- The study
  - analyzed text based testimonies of person of interests at military bases
  - used only text-based features (cues)

Text Mining Applications

- Application Case: Mining for Lies

Text Mining Applications

- Application Case: Mining for Lies

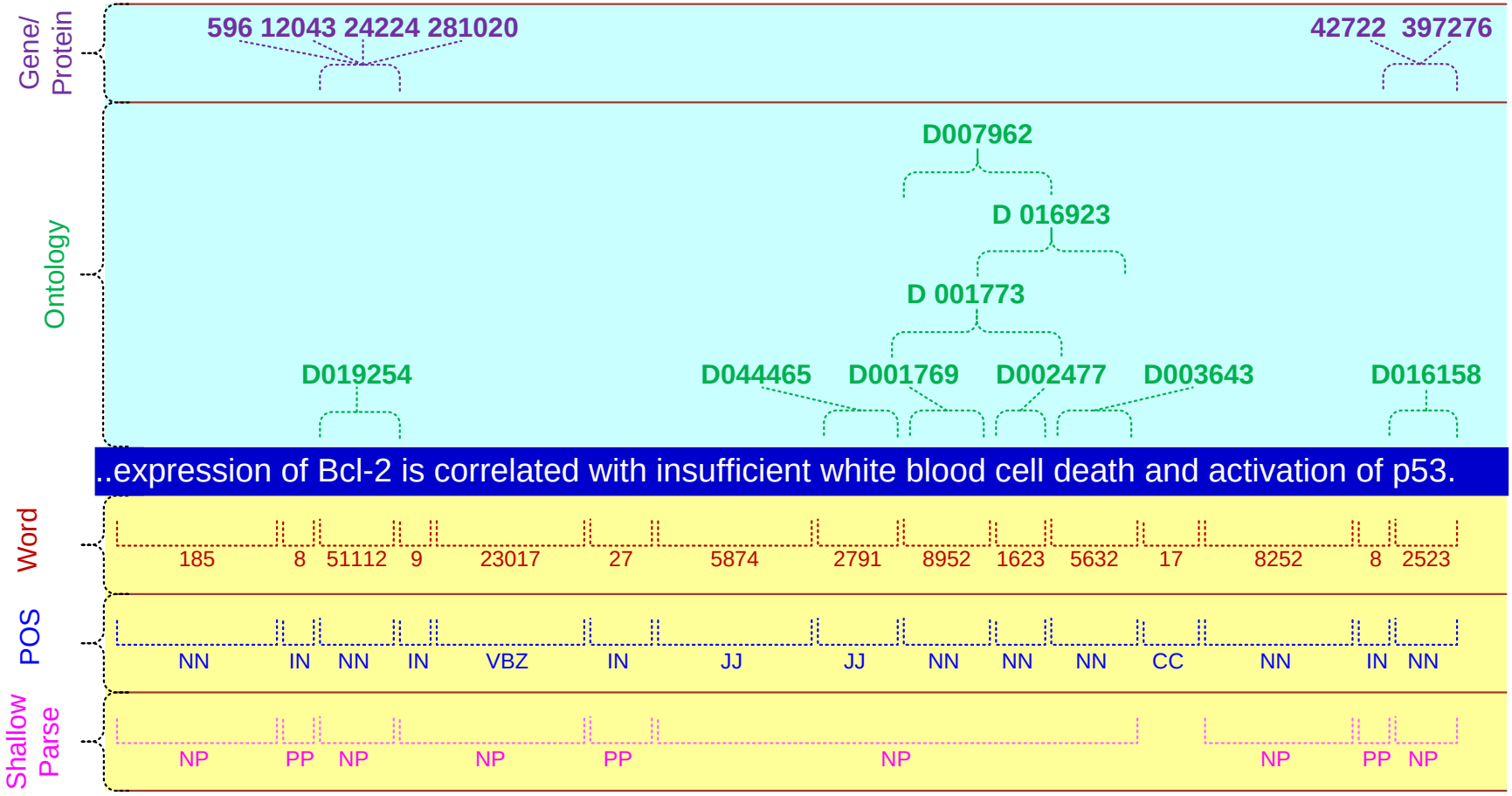
Category	Example Cues
Quantity	Verb count, noun-phrase count, ...
Complexity	Avg. no of clauses, sentence length, …
Uncertainty	Modifiers, modal verbs, ...
Nonimmediacy	Passive voice, objectification, ...
Expressivity	Emotiveness
Diversity	Lexical diversity, redundancy, ...
Informality	Typographical error ratio
Specificity	Spatiotemporal, perceptual information …
Affect	Positive affect, negative affect, etc.

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Applications

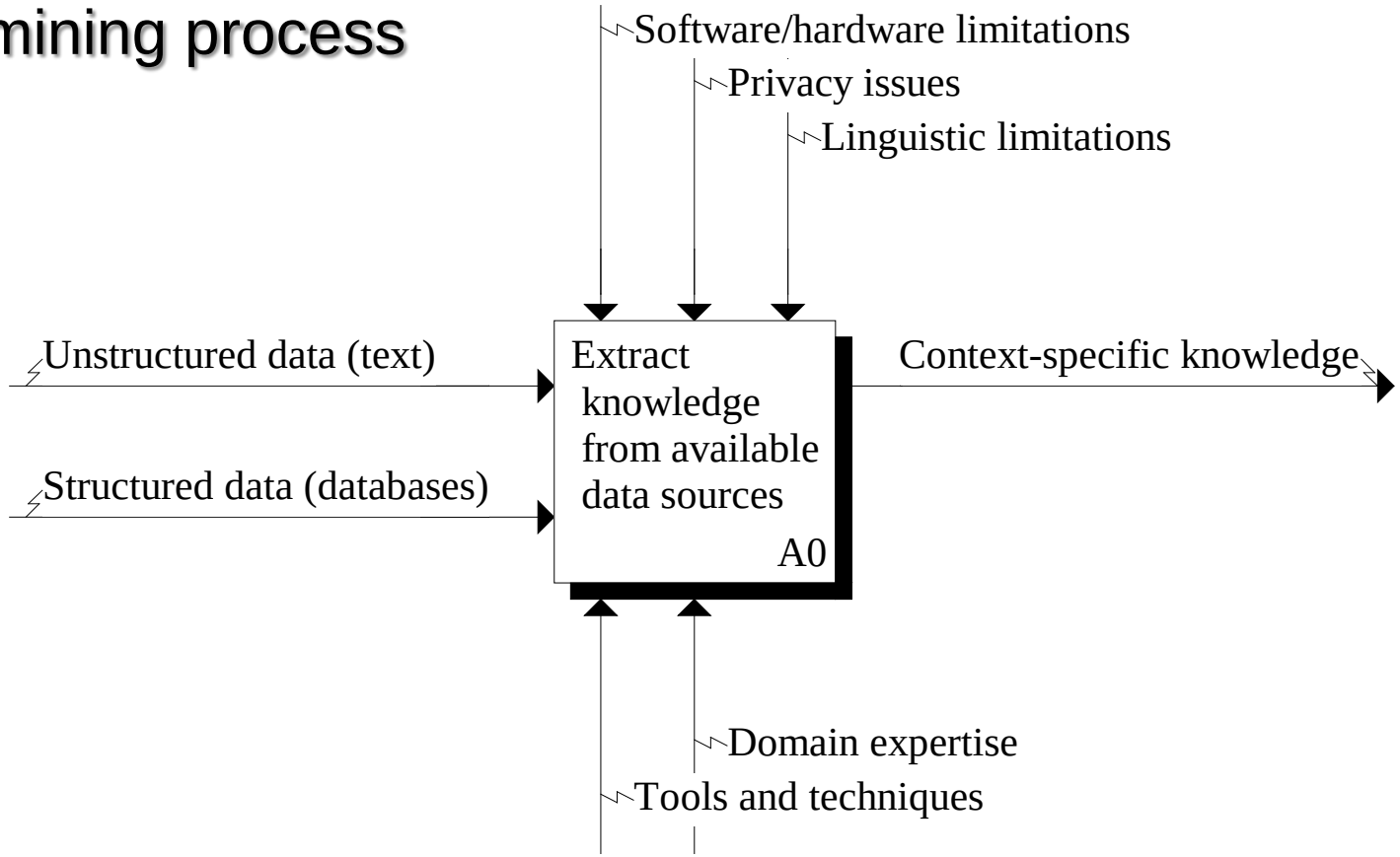
- Application Case: Mining for Lies
  - 371 usable statements are generated
  - 31 features are used
  - Different feature selection methods used
  - 10-fold cross validation is used
  - Results (overall % accuracy)
    - Logistic regression 67.28
    - Decision trees 71.60
    - Neural networks 73.46

Text Mining Applications
(gene/protein interaction identification)



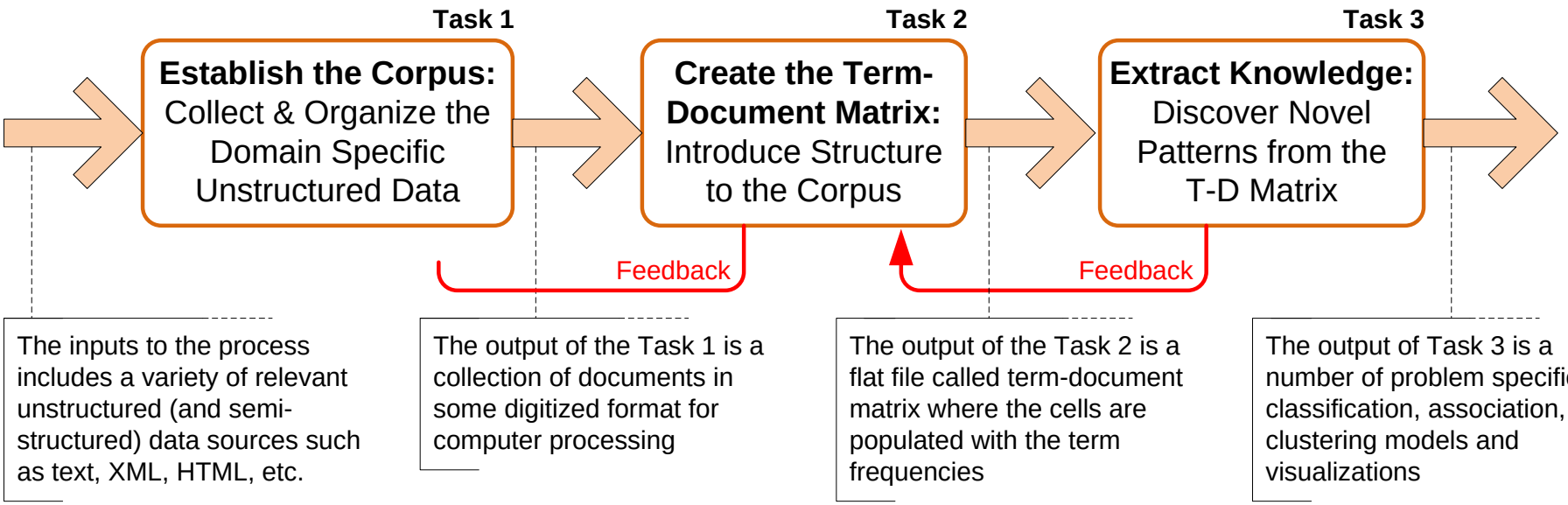
Text Mining Process

Context diagram for the text mining process



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Process



The three-step text mining process

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Process

- Step 1: Establish the corpus
  - Collect all relevant unstructured data (e.g., textual documents, XML files, emails, Web pages, short notes, voice recordings…)
  - Digitize, standardize the collection (e.g., all in ASCII text files)
  - Place the collection in a common place (e.g., in a flat file, or in a directory as separate files)

Text Mining Process

- Step 2: Create the Term–by–Document Matrix

Terms / Documents	investment risk	project management	software engineering	development	SAP	...	
Document 1	1			1			
Document 2		1					
Document 3			3		1		
Document 4		1					
Document 5			2	1			
Document 6	1			1			
...							

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Process

- Step 2: Create the Term–by–Document Matrix (TDM), cont.
  - Should all terms be included?
    - Stop words, include words
    - Synonyms, homonyms
    - Stemming
  - What is the best representation of the indices (values in cells)?
    - Row counts; binary frequencies; log frequencies;
    - Inverse document frequency

Text Mining Process

- Step 2: Create the Term–by–Document Matrix (TDM), cont.
  - TDM is a sparse matrix. How can we reduce the dimensionality of the TDM?
    - Manual - a domain expert goes through it
    - Eliminate terms with very few occurrences in very few documents (?)
    - Transform the matrix using singular value decomposition (SVD)
    - SVD is similar to principle component analysis

Text Mining Process

- Step 3: Extract patterns/knowledge
  - Classification (text categorization)
  - Clustering (natural groupings of text)
    - Improve search recall
    - Improve search precision
    - Scatter/gather
    - Query-specific clustering
  - Association
  - Trend Analysis (…)

Text Mining Application
(research trend identification in literature)

- Mining the published IS literature
  - MIS Quarterly (MISQ)
  - Journal of MIS (JMIS)
  - Information Systems Research (ISR)

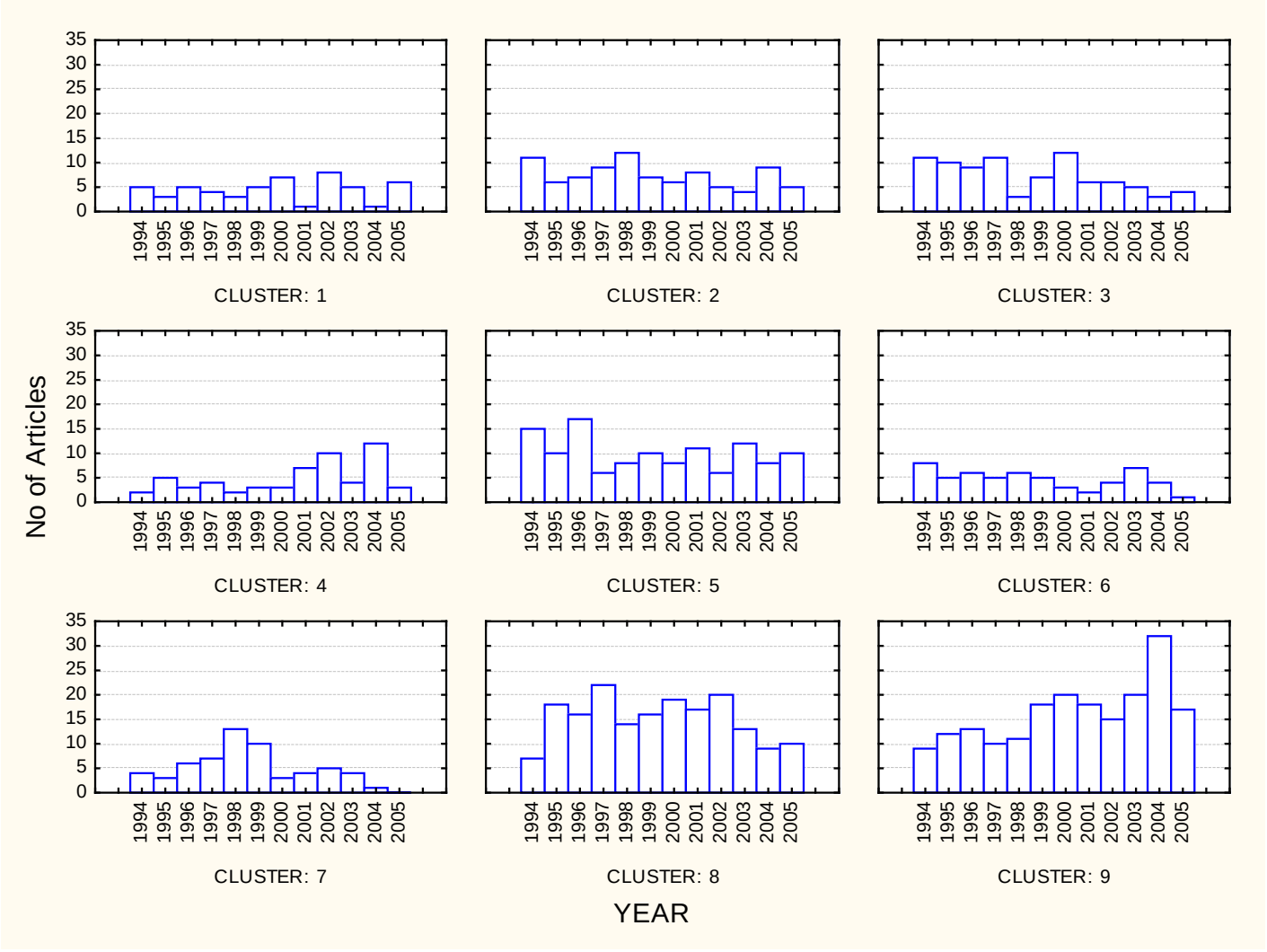
  - Covers 12-year period (1994-2005)
  - 901 papers are included in the study
  - Only the paper abstracts are used
  - 9 clusters are generated for further analysis

Text Mining Application
(research trend identification in literature)

Journal	Year	Author(s)	Title	Vol/No	Pages	Keywords	Abstract
MISQ	2005	A. Malhotra, S. Gosain and O. A. El Sawy	Absorptive capacity configurations in supply chains: Gearing for partner-enabled market knowledge creation	29/1	145-187	knowledge management supply chain absorptive capacity interorganizational information systems configuration approaches	The need for continual value innovation is driving supply chains to evolve from a pure transactional focus to leveraging interorganizational partner ships for sharing
ISR	1999	D. Robey and M. C. Boudreau	Accounting for the contradictory organizational consequences of information technology: Theoretical directions and methodological implications	2-Oct	167-185	organizational transformation impacts of technology organization theory research methodology intraorganizational power electronic communication mis implementation culture systems	Although much contemporary thought considers advanced information technologies as either determinants or enablers of radical organizational change, empirical studies have revealed inconsistent findings to support the deterministic logic implicit in such arguments. This paper reviews the contradictory
JMIS	2001	R. Aron and E. K. Clemons	Achieving the optimal balance between investment in quality and investment in self-promotion for information products	18/2	65-88	information products internet advertising product positioning signaling signaling games	When producers of goods (or services) are confronted by a situation in which their offerings no longer perfectly match consumer preferences, they must determine the extent to which the advertised features of
…	…	…	…	…	…	…	…

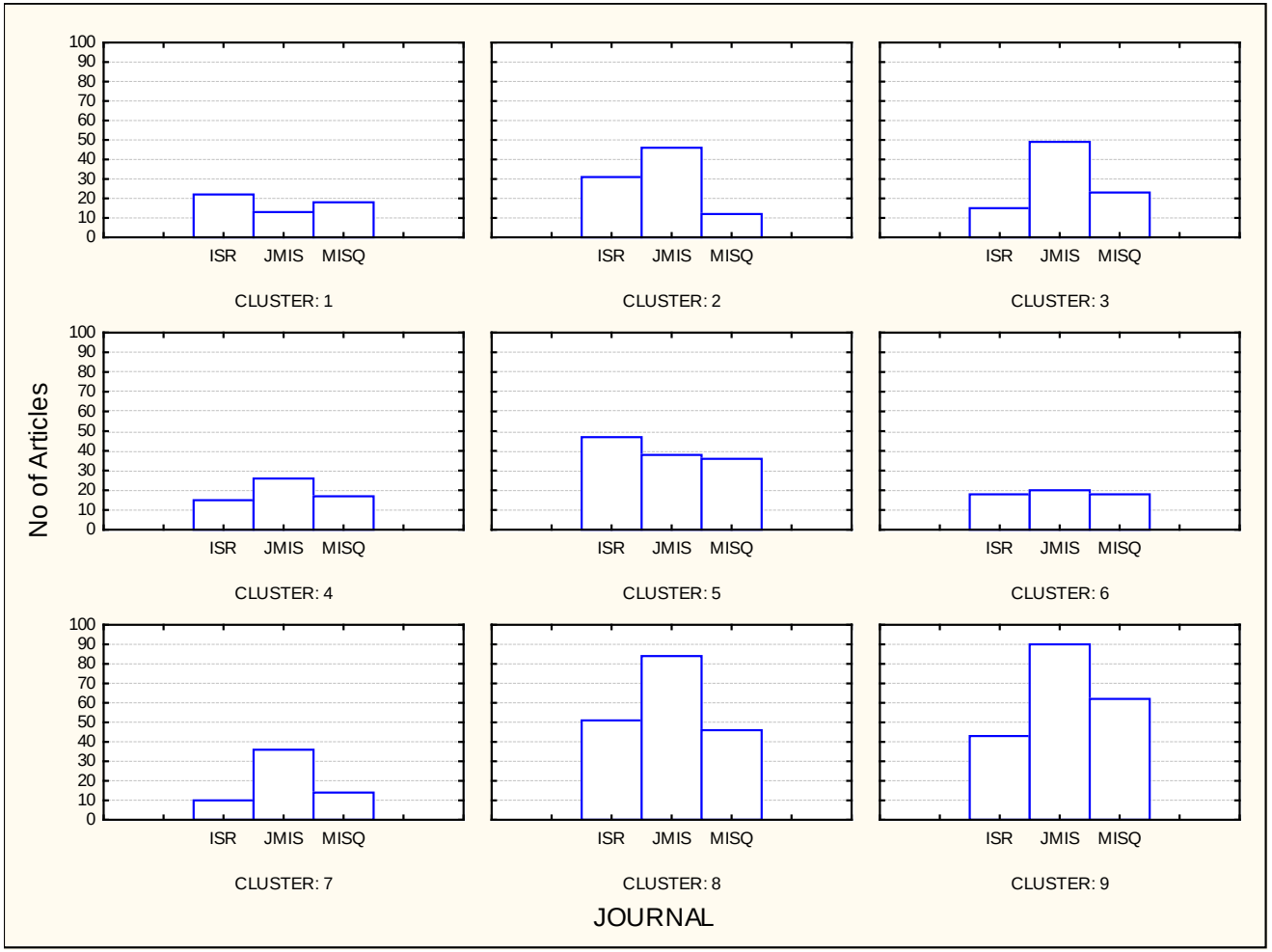
Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Application
(research trend identification in literature)



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Application
(research trend identification in literature)



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Text Mining Tools

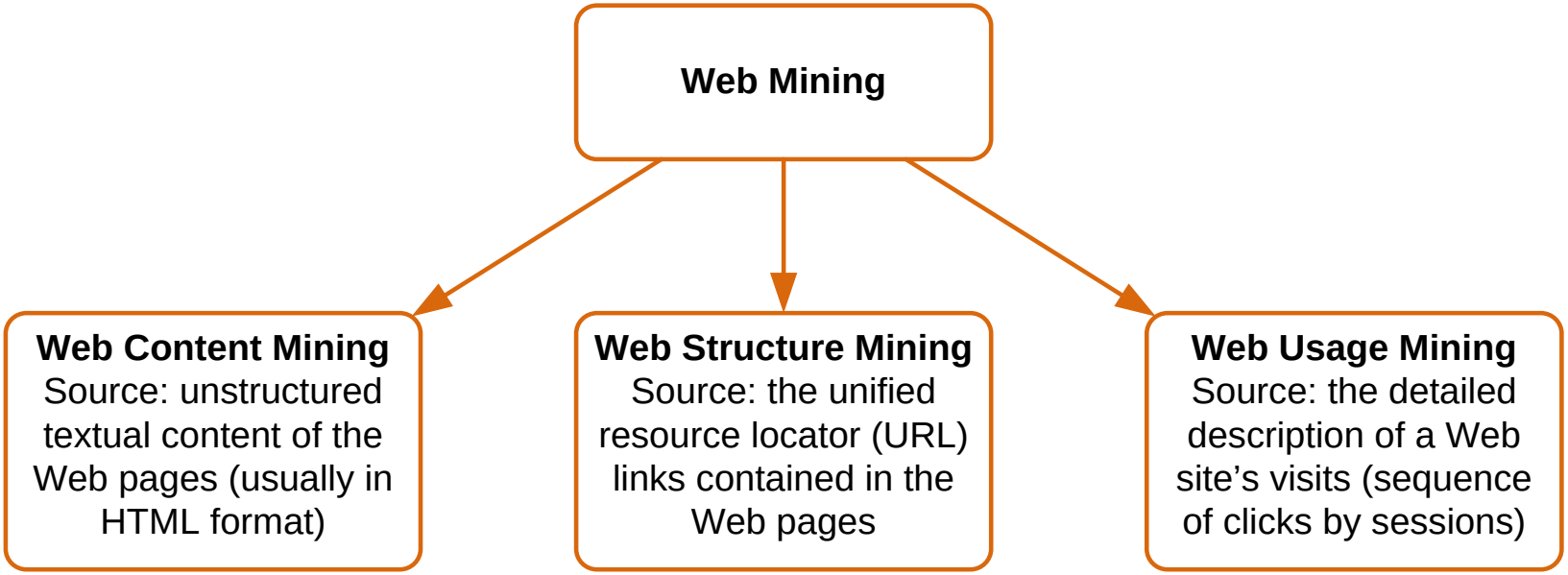
- Commercial Software Tools
  - SPSS PASW Text Miner
  - SAS Enterprise Miner
  - Statistica Data Miner
  - ClearForest, …
- Free Software Tools
  - RapidMiner
  - GATE
  - Spy-EM, …

Web Mining Overview

- Web is the largest repository of data
- Data is in HTML, XML, text format
- Challenges (of processing Web data)
  - The Web is too big for effective data mining
  - The Web is too complex
  - The Web is too dynamic
  - The Web is not specific to a domain
  - The Web has everything
- Opportunities and challenges are great!

Web Mining

- Web mining (or Web data mining) is the process of discovering intrinsic relationships from Web data (textual, linkage, or usage)



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Web Content/Structure Mining

- Mining of the textual content on the Web
- Data collection via Web crawlers

- Web pages include hyperlinks
  - Authoritative pages
  - Hubs
  - hyperlink-induced topic search (HITS) alg

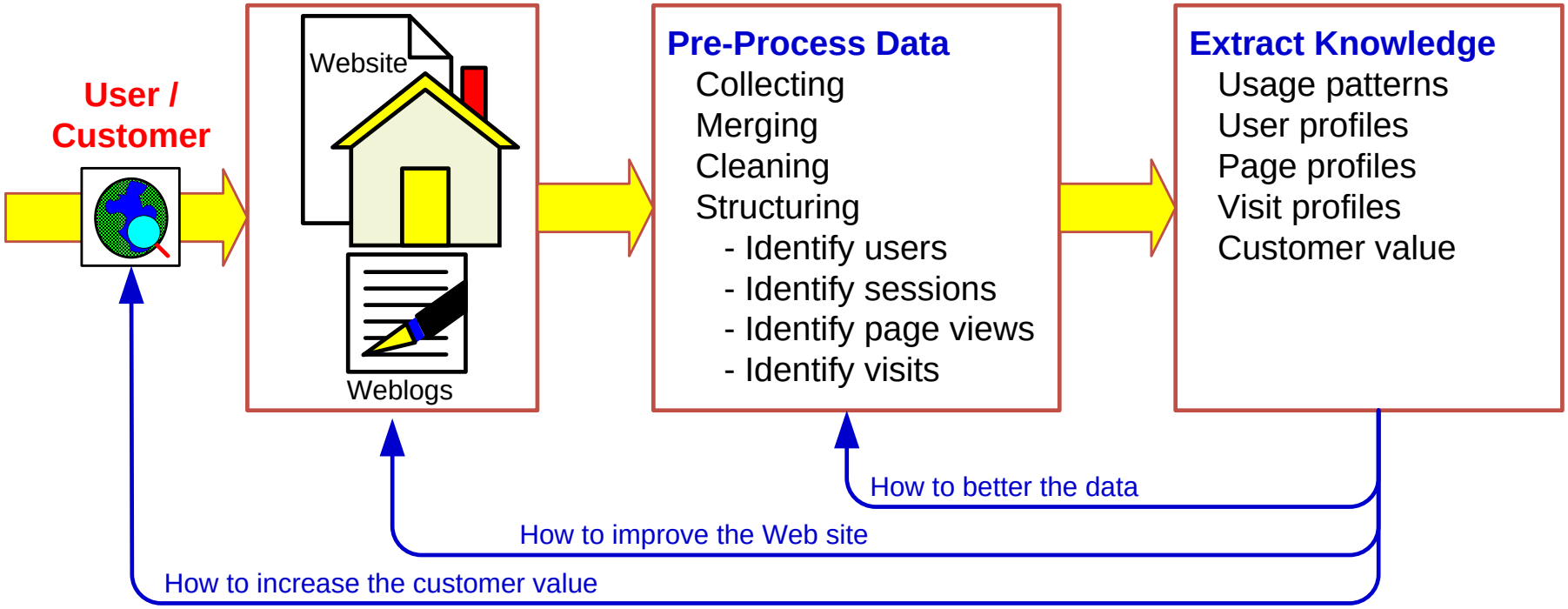
Web Usage Mining

- Extraction of information from data generated through Web page visits and transactions…
  - data stored in server access logs, referrer logs, agent logs, and client-side cookies
  - user characteristics and usage profiles
  - metadata, such as page attributes, content attributes, and usage data
- Clickstream data
- Clickstream analysis

Web Usage Mining

- Web usage mining applications
  - Determine the lifetime value of clients
  - Design cross-marketing strategies across products.
  - Evaluate promotional campaigns
  - Target electronic ads and coupons at user groups based on user access patterns
  - Predict user behavior based on previously learned rules and users' profiles
  - Present dynamic information to users based on their interests and profiles…

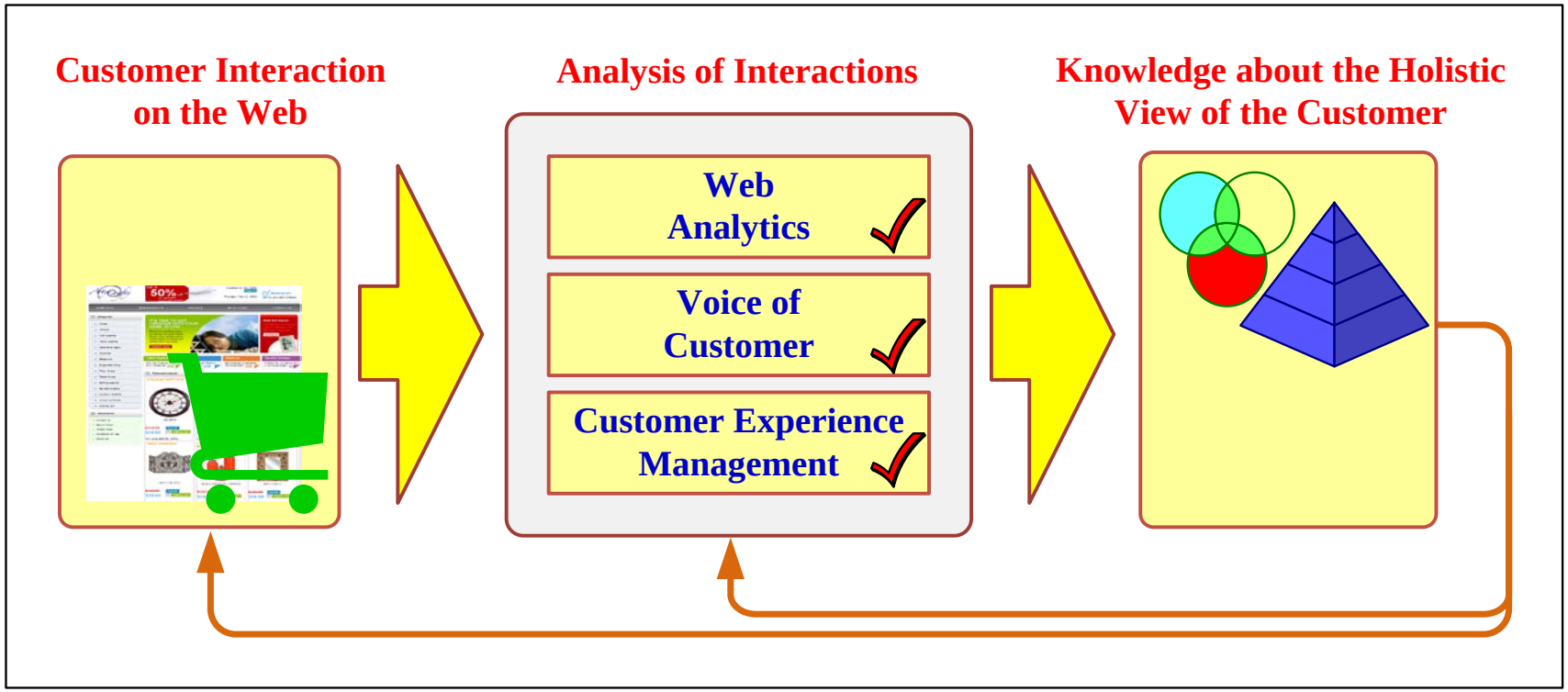
Web Usage Mining
(clickstream analysis)



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Web Mining Success Stories

- Amazon.com, Ask.com, Scholastic.com, …
- Website Optimization Ecosystem



Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Web Mining Tools

Product Name	URL
Angoss Knowledge WebMiner	angoss.com
ClickTracks	clicktracks.com
LiveStats from DeepMetrix	deepmetrix.com
Megaputer WebAnalyst	megaputer.com
MicroStrategy Web Traffic Analysis	microstrategy.com
SAS Web Analytics	sas.com
SPSS Web Mining for Clementine	spss.com
WebTrends	webtrends.com
XML Miner	scientio.com

Source: Turban et al. (2011), Decision Support and Business Intelligence Systems

Evaluation of Text Mining and Web Mining

- Evaluation of Information Retrieval
- Evaluation of Classification Model (Prediction)
  - Accuracy
  - Precision
  - Recall
  - F-score

Predictive Class (prediction outcome)	True Class (actual value): Positive	True Class (actual value): Negative	total
Positive	True Positive (TP)	False Positive (FP)	P’
Negative	True Negative (FN)	True Negative (TN)	N’
total	P	N	

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$True\ Positive\ Rate = \frac{TP}{TP + FN}$$

$$True\ Negative\ Rate = \frac{TN}{TN + FP}$$

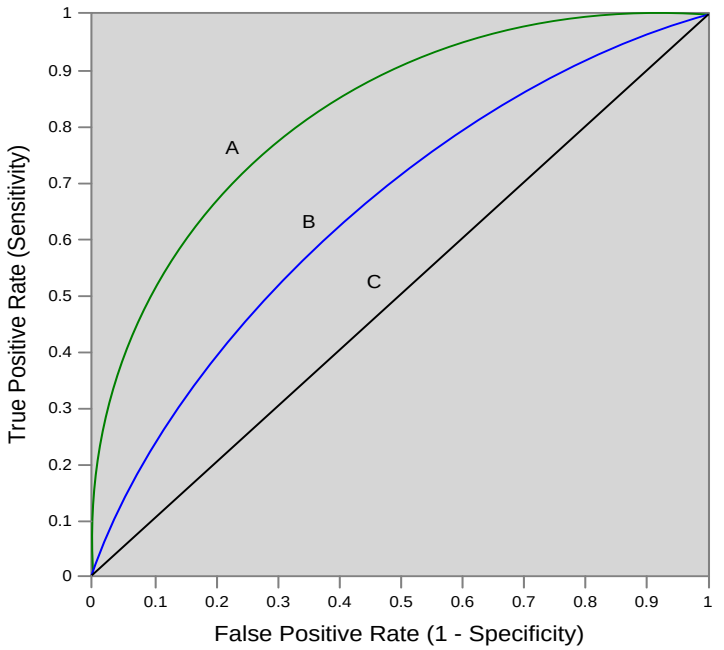
$$Precision = \frac{TP}{TP + FP} \qquad Recall = \frac{TP}{TP + FN}$$

$$True\ Positive\ Rate\ (\text{Sensitivity}) = \frac{TP}{TP + FN}$$

$$True\ Negative\ Rate\ (\text{Specificity}) = \frac{TN}{TN + FP}$$

$$False\ Positive\ Rate = \frac{FP}{FP + TN}$$

$$False\ Positive\ Rate\ (1\text{-Specificity}) = \frac{FP}{FP + TN}$$



Source: http://en.wikipedia.org/wiki/Receiver_operating_characteristic

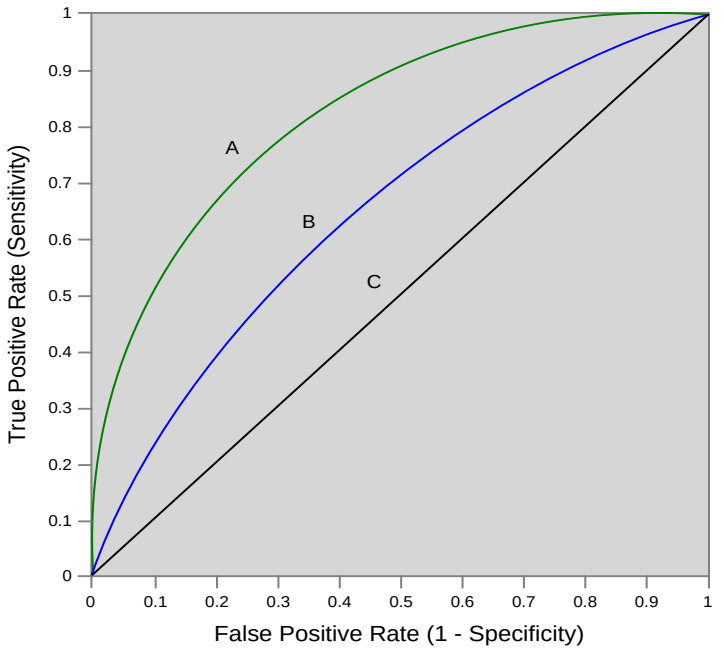
Predictive Class (prediction outcome)	True Class (actual value): Positive	True Class (actual value): Negative	total
Positive	True Positive (TP)	False Positive (FP)	P’
Negative	True Negative (FN)	True Negative (TN)	N’
total	P	N	

$$True\ Positive\ Rate\ (\text{Sensitivity}) = \frac{TP}{TP + FN}$$

Sensitivity
= True Positive Rate
= Recall
= Hit rate

$$True\ Positive\ Rate = \frac{TP}{TP + FN}$$

$$Recall = \frac{TP}{TP + FN}$$



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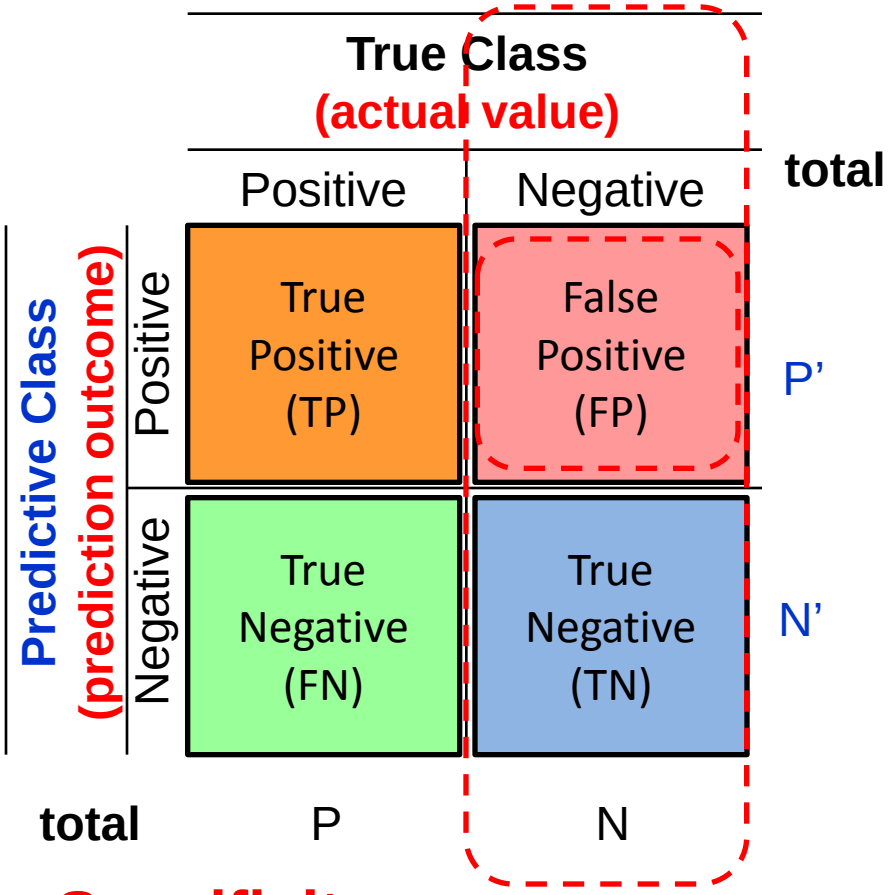
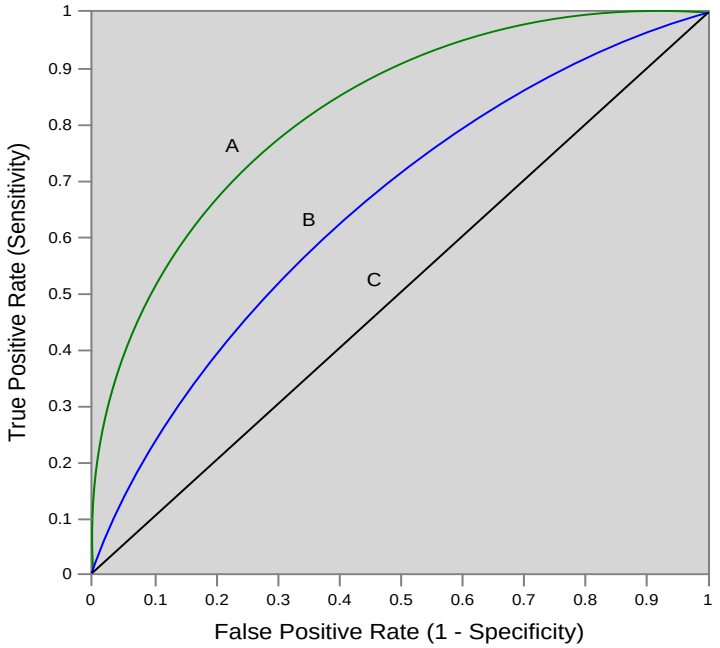


$$True\ Negative\ Rate = \frac{TN}{TN + FP}$$



Source: http://en.wikipedia.org/wiki/Receiver_operating_characteristic

Specificity

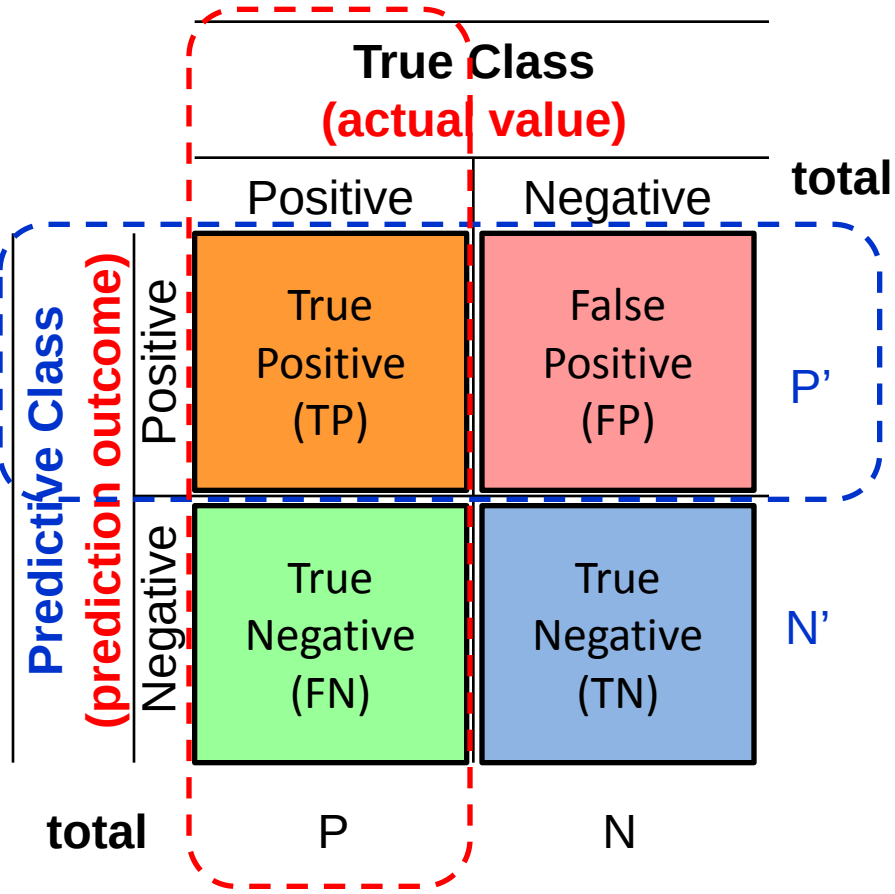
= True Negative Rate

= TN / N

= TN / (TP + TN)

$$True\ Negative\ Rate\ (\text{Specificity}) = \frac{TN}{TN + FP}$$

$$False\ Positive\ Rate\ (1\text{-Specificity}) = \frac{FP}{FP + TN}$$



Precision

= Positive Predictive Value (PPV)

$$Precision = \frac{TP}{TP + FP}$$

Recall

= True Positive Rate (TPR)

= Sensitivity

= Hit Rate

$$Recall = \frac{TP}{TP + FN}$$

F1 score (F-score)(F-measure) is the harmonic mean of precision and recall

= 2TP / (P + P')

= 2TP / (2TP + FP + FN)

$$F = 2 * \frac{precision * recall}{precision + recall}$$

Source: http://en.wikipedia.org/wiki/Receiver_operating_characteristic

A

63 (TP)	28 (FP)	91
37 (FN)	72 (TN)	109
100	100	200

Recall
= True Positive Rate (TPR)
= Sensitivity
= Hit Rate

Specificity
= True Negative Rate
= TN / N
= TN / (TP + TN)

TPR = 0.63

$$Recall = \frac{TP}{TP + FN}$$

$$True\ Negative\ Rate\ (\text{Specificity}) = \frac{TN}{TN + FP}$$

FPR = 0.28

$$False\ Positive\ Rate\ (1\text{-Specificity}) = \frac{FP}{FP + TN}$$

PPV = 0.69
=63/(63+28)
=63/91

$$Precision = \frac{TP}{TP + FP}$$

Precision
= Positive Predictive Value (PPV)

F1 = 0.66
= 2*(0.63*0.69)/(0.63+0.69)
= (2 * 63) /(100 + 91)
= (0.63 + 0.69) / 2 =1.32 / 2 =0.66

$$F = 2 * \frac{precision * recall}{precision + recall}$$

F1 score (F-score) (F-measure)
is the harmonic mean of precision and recall
= 2TP / (P + P')
= 2TP / (2TP + FP + FN)

ACC = 0.68
= (63 + 72) / 200
= 135/200 = 67.5

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Source: http://en.wikipedia.org/wiki/Receiver_operating_characteristic

A

63 (TP)	28 (FP)	91
37 (FN)	72 (TN)	109
100	100	200

TPR = 0.63

FPR = 0.28

PPV = 0.69

=63/(63+28)

=63/91

F1 = 0.66

= 2*(0.63*0.69)/(0.63+0.69)

= (2 * 63) /(100 + 91)

= (0.63 + 0.69) / 2 =1.32 / 2 =0.66

ACC = 0.68

= (63 + 72) / 200

= 135/200 = 67.5

B

77 (TP)	77 (FP)	154
23 (FN)	23 (TN)	46
100	100	200

TPR = 0.77

FPR = 0.77

PPV = 0.50

F1 = 0.61

ACC = 0.50

Source: http://en.wikipedia.org/wiki/Receiver_operating_characteristic

C

24 (TP)	88 (FP)	112
76 (FN)	12 (TN)	88
100	100	200

TPR = 0.24
FPR = 0.88
PPV = 0.21
F1 = 0.22
ACC = 0.18

C'

76 (TP)	12 (FP)	88
24 (FN)	88 (TN)	112
100	100	200

TPR = 0.76
FPR = 0.12
PPV = 0.86
F1 = 0.81
ACC = 0.82

Source: http://en.wikipedia.org/wiki/Receiver_operating_characteristic

Summary

- Text Mining
- Web Mining

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