

Data Mining:

Concepts and Techniques

(3rd ed.)

— Chapter 1 —

Jiawei Han, Micheline Kamber, and Jian Pei
University of Illinois at Urbana-Champaign &
Simon Fraser University

©2010 Han, Kamber & Pei. All rights reserved.



Data and Information Systems (DAIS:) Course Structures at CS/UIUC

- Coverage: Database, data mining, text information systems, Web and bioinformatics
- Data mining
 - Intro. to data warehousing and mining (CS412: Han—Fall)
 - Data mining: Principles and algorithms (CS512: Han—Spring)
 - Seminar: Advanced Topics in Data mining (CS591Han—Fall and Spring. 1 credit unit)
 - Independent Study: only if you seriously plan to do your Ph.D./M.S. on data mining and try to demonstrate your ability
- Database Systems:
 - Introd. to database systems (CS411: Kevin Chang + Others: Fall and Spring)
 - Advanced database systems (CS511: Kevin Chang Fall' 11)
- Text information systems
 - Text information system (CS410 ChengXiang Zhai: Spring)
- Bioinformatics
 - Introduction to BioInformatics (Saurabh Sinha)
 - CS591 Seminar on Bioinformatics (Sinha: 1 credit unit)
- Yahoo!-DAIS seminar (CS591DAIS—Fall and Spring. 1 credit unit)

CS412 Coverage (Chapters 1-7 of the TextBook)

- The textbook book will be covered in two courses at CS, UIUC
 - CS412: **Introduction to Data Mining (Fall)** [Chapters 1-10]
 - CS512: **Data Mining: Principles and Algorithms (Spring)** [Chaps. 11-13]
- CS412 Coverage (BK2: 2nd Ed.)
 - Introduction
 - Data Preprocessing
 - Data Warehouse and OLAP Technology: An Introduction
 - Advanced Data Cube Technology and Data Generalization
 - Mining Frequent Patterns, Association and Correlations
 - Classification and Prediction
 - Cluster Analysis
- CS412 Coverage (BK3: 3rd ed.)
 1. Introduction
 2. Getting to Know Your Data
 3. Data Preprocessing
 4. Data Warehouse and OLAP Technology: An Introduction
 5. Advanced Data Cube Technology
 6. Mining Frequent Patterns & Association: Basic Concepts
 7. Mining Frequent Patterns & Association: Advanced Methods
 8. Classification: Basic Concepts
 9. Classification: Advanced Methods
 10. Cluster Analysis: Basic Concepts
 11. Cluster Analysis: Advanced Methods (CS512)
 12. Outlier Analysis (CS512)

CS512 Coverage (Chapters 11, 12, 13 + More Advanced Topics)

- Cluster Analysis: Advanced Methods (Chapter 11)
- Outlier Analysis (Chapter 12)
- Mining data streams, time-series, and sequence data
- Mining graph data
- Mining social and information networks
- Mining object, spatial, multimedia, text and Web data
 - Mining complex data objects
 - Spatial and spatiotemporal data mining
 - Multimedia data mining
 - Text and Web mining
- Additional (often current) themes if time permits



Jiawei Han

Professor, [Department of Computer Science](#)
[Univ. of Illinois at Urbana-Champaign](#)
[Rm 2132, Siebel Center for Computer Science](#)
201 N. Goodwin Avenue
Urbana, IL 61801, USA
E-mail: [hanj\[at\]cs.uiuc.edu](mailto:hanj[at]cs.uiuc.edu)

Ph.D. (1985), Computer Science, Univ. Wisconsin-Madison

Knowledge Discovery and Data Mining, Database Systems

[Data Mining Research Group](#)
[Data and Information Systems Research Laboratory](#)
UIUC Calendar: [\(10-11\)](#) [\(11-12\)](#) ([Cites: Exchange](#)) ([CS Portal](#))
Office: (217) 333-6903
Fax: (217) 265-6494
Web: www.cs.uiuc.edu/homes/hanj
[Schedule: Meetings and Appointments](#)

● [Current Research](#) (Selected Publications)

- [Information Network Analysis and Discovery](#) (Information Network Academic Research Center: [Network Science-Collaborative Technology Alliance](#)) ([NSF IIS Infonet Project](#))
- [Knowledge Discovery in Cyberphysical Systems](#) (NSF/CPS)
- [MoveMine: Mining Sophisticated Patterns and Actionable Knowledge from Massive Moving Object Data](#) (NSF/IIS)
- [Assured Information Sharing Lifecycle](#) (MURI: AISL)
- [OLAPing and Multi-Dimensional Analysis of Text Data](#) (CS-BibCube) ([Event Cube: NASA](#))
- [Sequential and Structured Pattern Discovery: Classification, Clustering and Outlier Analysis](#)
- [Discovery of the Dynamics of Data Streams in Multi-Dimensional Space](#)
- [Multidimensional Analysis and Ranking in Databases, Web, and Other Information Repositories](#)

● Teaching

- [UIUC CS412: An Introduction to Data Warehousing and Data Mining \(Fall 2011\)](#) 3:30-4:45pm WF 1404 Siebel Center (every Fall semester)

CS 412. Course Page & Class Schedule

- Class Homepage: <https://wiki.engr.illinois.edu/display/cs412>
- Wiki course outline
 - Course Information
 - **Course Schedule** (Fall_2011)
 - Lecture media (Fall_2011)
 - Assignments (Fall 2011)
 - Resources and Reading Lists
 - Staff
 - Project [Only for students taking 4 credits for the course]
 - **Comments and Suggestions**—Textbook, Slides, Class Presentation, and Teaching
 - **Class-Related Questions and Answers**

CS 412: Course Project [4th credit]

- Survey:
 - Writing a comprehensive survey on a focused topic, e.g., clustering heterogeneous information networks
- Quiz maker:
 - Making excellent quiz questions and answers for selected chapters of the course (Chapters 1-10)
- Software maker:
 - Implementing one high-performance, fully documented open source data mining function for those taught in the book, in Java/C++, including user-interfaces and visualization package [Note: No plagiarism!]
- Answer book maker:
 - Enhancing and making answers for exercise questions in the book [Assigned to three students already]

Chapter 1. Introduction

- Why Data Mining? 
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

Why Data Mining?




- The Explosive Growth of Data: from terabytes to petabytes
 - Data collection and data availability
 - Automated data collection tools, database systems, Web, computerized society
 - Major sources of abundant data
 - Business: Web, e-commerce, transactions, stocks, ...
 - Science: Remote sensing, bioinformatics, scientific simulation, ...
 - Society and everyone: news, digital cameras, YouTube
- We are drowning in data, but starving for knowledge!
- “Necessity is the mother of invention”—Data mining—Automated analysis of massive data sets

Evolution of Sciences: New Data Science Era

- Before 1600: **Empirical science**
- 1600-1950s: **Theoretical science**
 - Each discipline has grown a *theoretical* component. Theoretical models often motivate experiments and generalize our understanding.
- 1950s-1990s: **Computational science**
 - Over the last 50 years, most disciplines have grown a third, *computational* branch (e.g. empirical, theoretical, and computational ecology, or physics, or linguistics.)
 - Computational Science traditionally meant simulation. It grew out of our inability to find closed-form solutions for complex mathematical models.
- 1990-now: **Data science**
 - The flood of data from new scientific instruments and simulations
 - The ability to economically store and manage petabytes of data online
 - The Internet and computing Grid that makes all these archives universally accessible
 - Scientific info. management, acquisition, organization, query, and visualization tasks scale almost linearly with data volumes
 - **Data mining** is a major new challenge!
- Jim Gray and Alex Szalay, *The World Wide Telescope: An Archetype for Online Science*, Comm. ACM, 45(11): 50-54, Nov. 2002

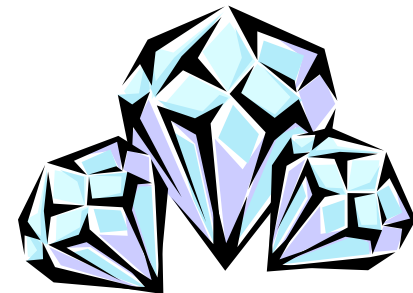
Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining? 
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

What Is Data Mining?

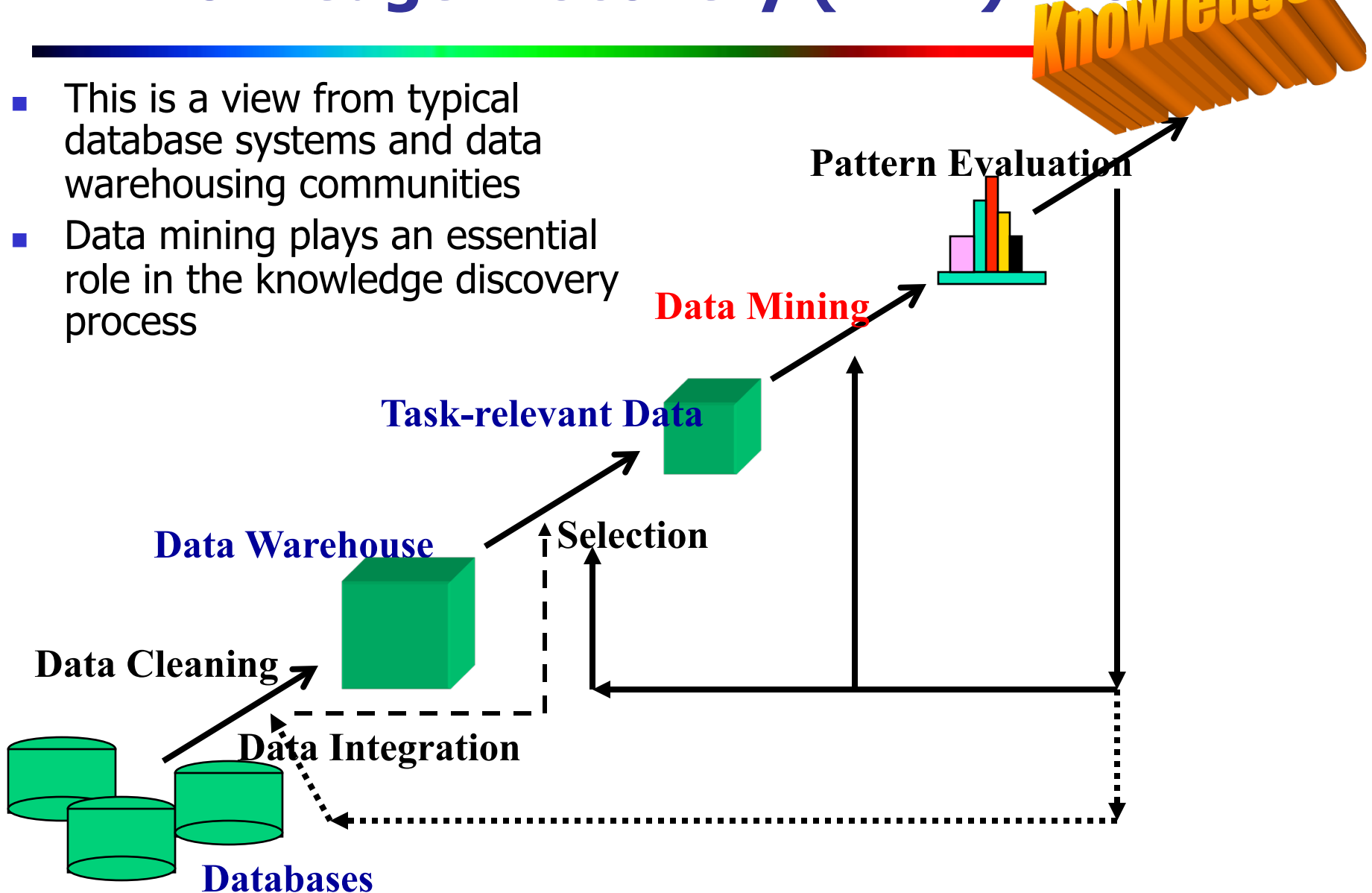


- Data mining (knowledge discovery from data)
 - Extraction of interesting (non-trivial, implicit, previously unknown and potentially useful) patterns or knowledge from huge amount of data
 - Data mining: a misnomer?
- Alternative names
 - Knowledge discovery (mining) in databases (KDD), knowledge extraction, data/pattern analysis, data archeology, data dredging, information harvesting, business intelligence, etc.
- Watch out: Is everything “data mining”?
 - Simple search and query processing
 - (Deductive) expert systems



Knowledge Discovery (KDD) Process

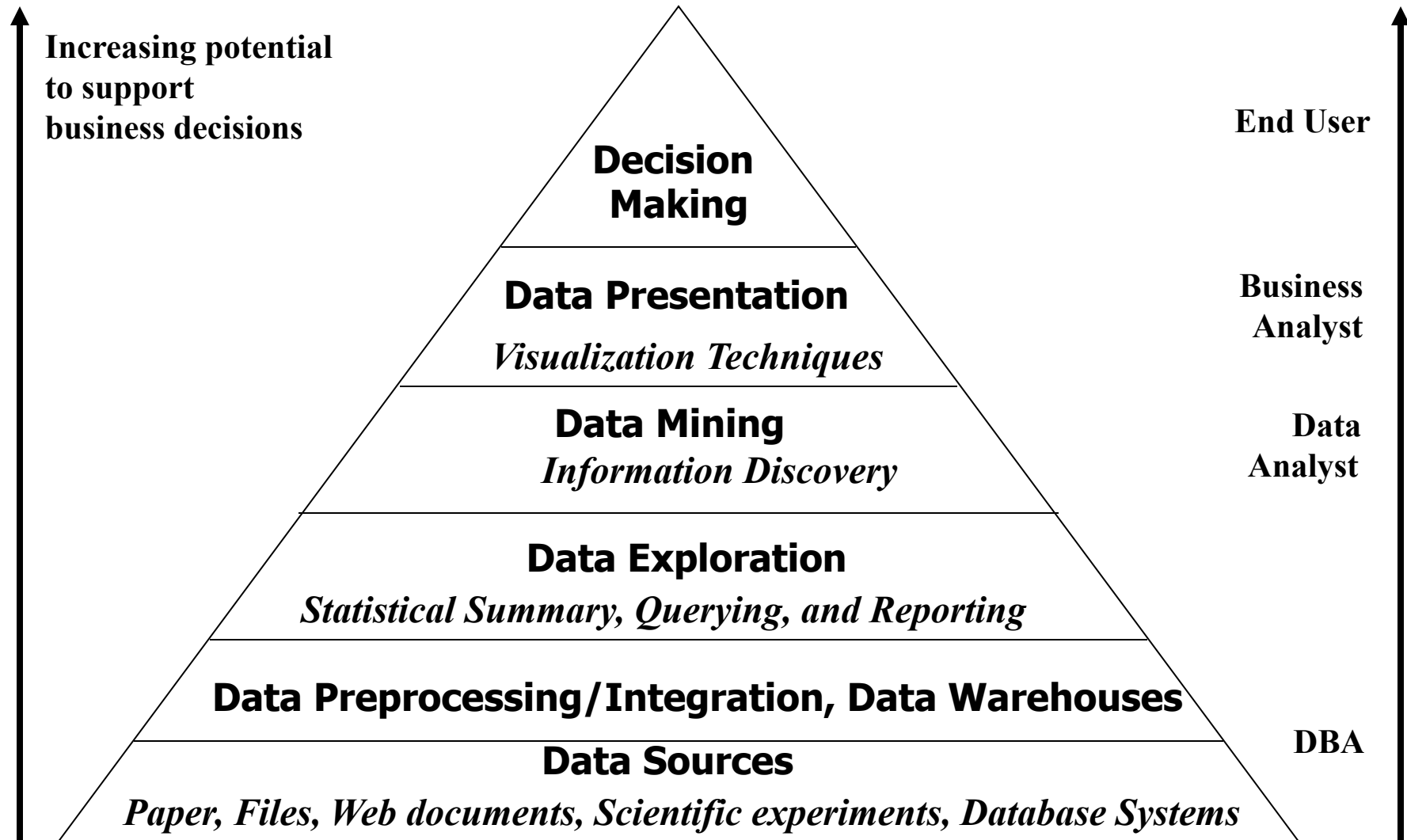
- This is a view from typical database systems and data warehousing communities
- Data mining plays an essential role in the knowledge discovery process



Example: A Web Mining Framework

- Web mining usually involves
 - Data cleaning
 - Data integration from multiple sources
 - Warehousing the data
 - Data cube construction
 - Data selection for data mining
 - Data mining
 - Presentation of the mining results
 - Patterns and knowledge to be used or stored into knowledge-base

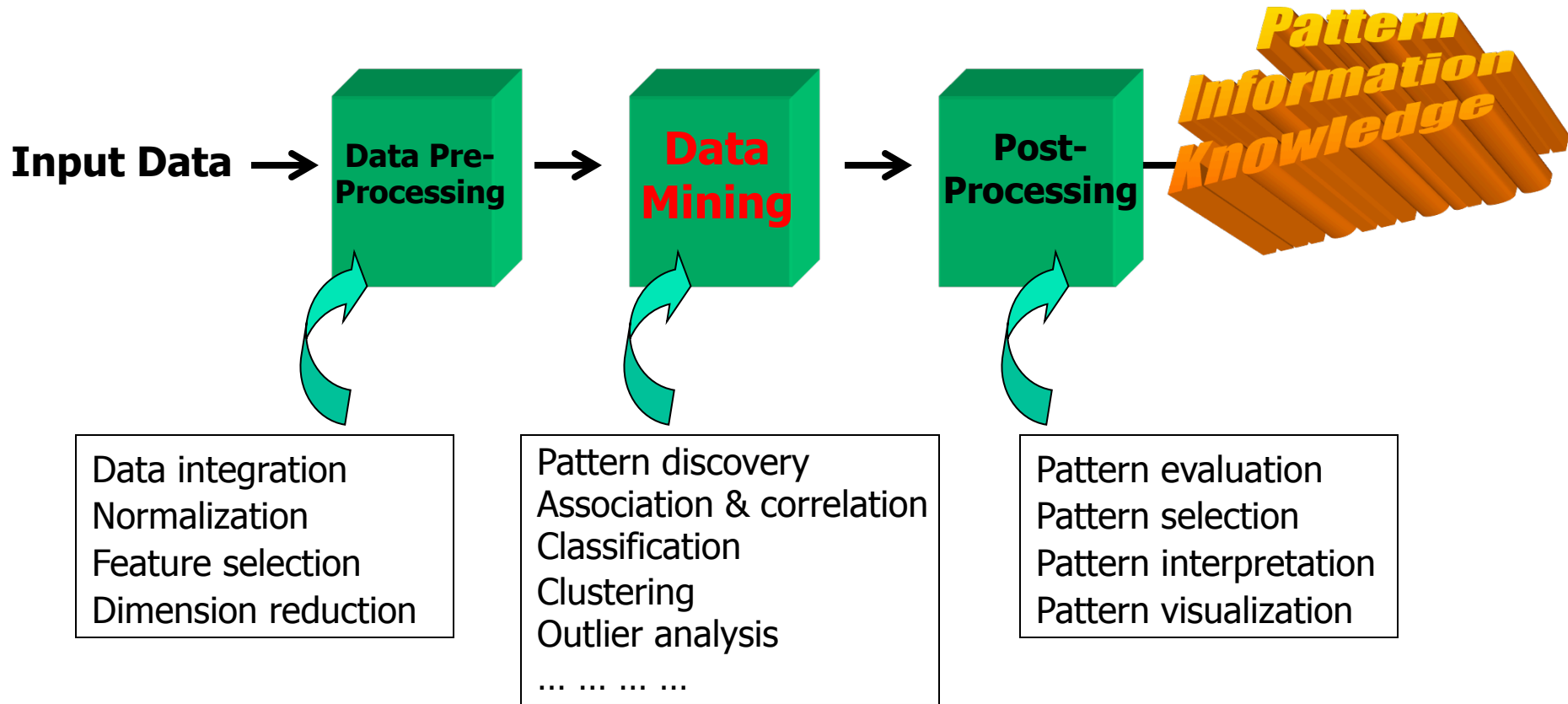
Data Mining in Business Intelligence



Example: Mining vs. Data Exploration

- Business intelligence view
 - Warehouse, data cube, reporting but not much mining
- Business objects vs. data mining tools
- Supply chain example: tools
- Data presentation
- Exploration

KDD Process: A Typical View from ML and Statistics




- This is a view from typical machine learning and statistics communities

Example: Medical Data Mining

- Health care & medical data mining – often adopted such a view in statistics and machine learning
- Preprocessing of the data (including feature extraction and dimension reduction)
- Classification or/and clustering processes
- Post-processing for presentation

Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining 
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

Multi-Dimensional View of Data Mining

■ Data to be mined

- Database data (extended-relational, object-oriented, heterogeneous, legacy), data warehouse, transactional data, stream, spatiotemporal, time-series, sequence, text and web, multi-media, graphs & social and information networks

■ Knowledge to be mined (or: Data mining functions)

- Characterization, discrimination, association, classification, clustering, trend/deviation, outlier analysis, etc.
- Descriptive vs. predictive data mining
- Multiple/integrated functions and mining at multiple levels


■ Techniques utilized

- Data-intensive, data warehouse (OLAP), machine learning, statistics, pattern recognition, visualization, high-performance, etc.

■ Applications adapted

- Retail, telecommunication, banking, fraud analysis, bio-data mining, stock market analysis, text mining, Web mining, etc.


Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined? 
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

Data Mining: On What Kinds of Data?

- Database-oriented data sets and applications
 - Relational database, data warehouse, transactional database
- Advanced data sets and advanced applications
 - Data streams and sensor data
 - Time-series data, temporal data, sequence data (incl. bio-sequences)
 - Structure data, graphs, social networks and multi-linked data
 - Object-relational databases
 - Heterogeneous databases and legacy databases
 - Spatial data and spatiotemporal data
 - Multimedia database
 - Text databases
 - The World-Wide Web

Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined? 
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

Data Mining Function: (1) Generalization

- Information integration and data warehouse construction
 - Data cleaning, transformation, integration, and multidimensional data model
- Data cube technology
 - Scalable methods for computing (i.e., materializing) multidimensional aggregates
 - OLAP (online analytical processing)
- Multidimensional concept description: Characterization and discrimination
 - Generalize, summarize, and contrast data characteristics, e.g., dry vs. wet region

Data Mining Function: (2) Association and Correlation Analysis

- Frequent patterns (or frequent itemsets)
 - What items are frequently purchased together in your Walmart?
- Association, correlation vs. causality
 - A typical association rule
 - Diaper \rightarrow Beer [0.5%, 75%] (support, confidence)
 - Are strongly associated items also strongly correlated?
- How to mine such patterns and rules efficiently in large datasets?
- How to use such patterns for classification, clustering, and other applications?

Data Mining Function: (3) Classification

- Classification and label prediction
 - Construct models (functions) based on some training examples
 - Describe and distinguish classes or concepts for future prediction
 - E.g., classify countries based on (climate), or classify cars based on (gas mileage)
 - Predict some unknown class labels
- Typical methods
 - Decision trees, naïve Bayesian classification, support vector machines, neural networks, rule-based classification, pattern-based classification, logistic regression, ...
- Typical applications:
 - Credit card fraud detection, direct marketing, classifying stars, diseases, web-pages, ...

Data Mining Function: (4) Cluster Analysis

- Unsupervised learning (i.e., Class label is unknown)
- Group data to form new categories (i.e., clusters), e.g., cluster houses to find distribution patterns
- Principle: Maximizing intra-class similarity & minimizing interclass similarity
- Many methods and applications

Data Mining Function: (5) Outlier Analysis

- Outlier analysis
 - Outlier: A data object that does not comply with the general behavior of the data
 - Noise or exception? — One person's garbage could be another person's treasure
 - Methods: by product of clustering or regression analysis, ...
 - Useful in fraud detection, rare events analysis

Time and Ordering: Sequential Pattern, Trend and Evolution Analysis

- Sequence, trend and evolution analysis
 - Trend, time-series, and deviation analysis: e.g., regression and value prediction
 - Sequential pattern mining
 - e.g., first buy digital camera, then buy large SD memory cards
 - Periodicity analysis
 - Motifs and biological sequence analysis
 - Approximate and consecutive motifs
 - Similarity-based analysis
- Mining data streams
 - Ordered, time-varying, potentially infinite, data streams

Structure and Network Analysis

- Graph mining
 - Finding frequent subgraphs (e.g., chemical compounds), trees (XML), substructures (web fragments)
- Information network analysis
 - Social networks: actors (objects, nodes) and relationships (edges)
 - e.g., author networks in CS, terrorist networks
 - Multiple heterogeneous networks
 - A person could be multiple information networks: friends, family, classmates, ...
 - Links carry a lot of semantic information: Link mining
- Web mining
 - Web is a big information network: from PageRank to Google
 - Analysis of Web information networks
 - Web community discovery, opinion mining, usage mining, ...

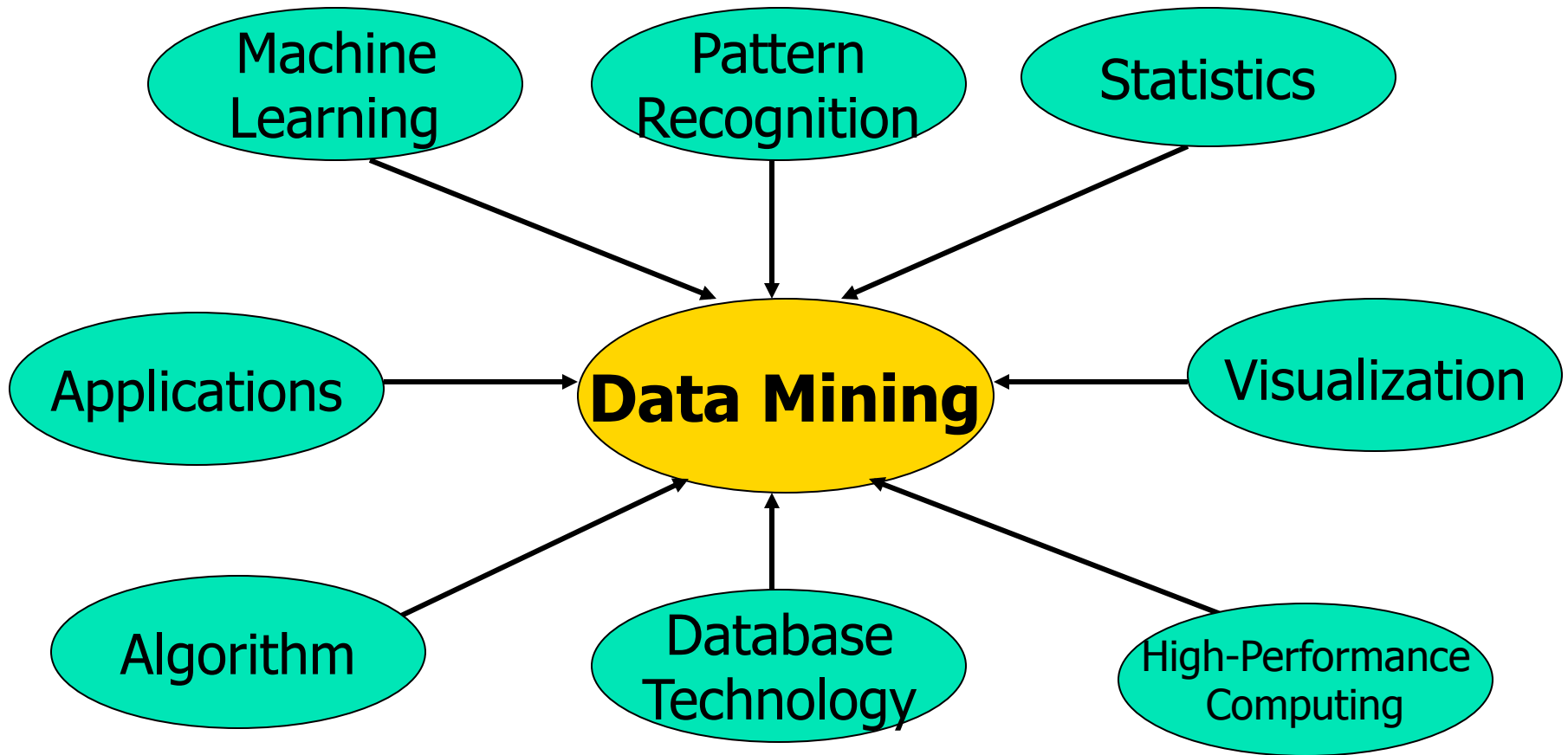
Evaluation of Knowledge

- Are all mined knowledge interesting?
 - One can mine tremendous amount of “patterns” and knowledge
 - Some may fit only certain dimension space (time, location, ...)
 - Some may not be representative, may be transient, ...
- Evaluation of mined knowledge → directly mine only interesting knowledge?
 - Descriptive vs. predictive
 - Coverage
 - Typicality vs. novelty
 - Accuracy
 - Timeliness
 - ...

Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used? 
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

Data Mining: Confluence of Multiple Disciplines



Why Confluence of Multiple Disciplines?

- Tremendous amount of data
 - Algorithms must be highly scalable to handle such as tera-bytes of data
- High-dimensionality of data
 - Micro-array may have tens of thousands of dimensions
- High complexity of data
 - Data streams and sensor data
 - Time-series data, temporal data, sequence data
 - Structure data, graphs, social networks and multi-linked data
 - Heterogeneous databases and legacy databases
 - Spatial, spatiotemporal, multimedia, text and Web data
 - Software programs, scientific simulations
- New and sophisticated applications


Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted? 
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

Applications of Data Mining

- Web page analysis: from web page classification, clustering to PageRank & HITS algorithms
- Collaborative analysis & recommender systems
- Basket data analysis to targeted marketing
- Biological and medical data analysis: classification, cluster analysis (microarray data analysis), biological sequence analysis, biological network analysis
- Data mining and software engineering (e.g., IEEE Computer, Aug. 2009 issue)
- From major dedicated data mining systems/tools (e.g., SAS, MS SQL-Server Analysis Manager, Oracle Data Mining Tools) to invisible data mining

Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining 
- A Brief History of Data Mining and Data Mining Society
- Summary

Major Issues in Data Mining (1)

- Mining Methodology
 - Mining various and new kinds of knowledge
 - Mining knowledge in multi-dimensional space
 - Data mining: An interdisciplinary effort
 - Boosting the power of discovery in a networked environment
 - Handling noise, uncertainty, and incompleteness of data
 - Pattern evaluation and pattern- or constraint-guided mining
- User Interaction
 - Interactive mining
 - Incorporation of background knowledge
 - Presentation and visualization of data mining results

Major Issues in Data Mining (2)

- Efficiency and Scalability
 - Efficiency and scalability of data mining algorithms
 - Parallel, distributed, stream, and incremental mining methods
- Diversity of data types
 - Handling complex types of data
 - Mining dynamic, networked, and global data repositories
- Data mining and society
 - Social impacts of data mining
 - Privacy-preserving data mining
 - Invisible data mining

Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary



A Brief History of Data Mining Society

- 1989 IJCAI Workshop on Knowledge Discovery in Databases
 - Knowledge Discovery in Databases (G. Piatetsky-Shapiro and W. Frawley, 1991)
- 1991-1994 Workshops on Knowledge Discovery in Databases
 - Advances in Knowledge Discovery and Data Mining (U. Fayyad, G. Piatetsky-Shapiro, P. Smyth, and R. Uthurusamy, 1996)
- 1995-1998 International Conferences on Knowledge Discovery in Databases and Data Mining (KDD' 95-98)
 - Journal of Data Mining and Knowledge Discovery (1997)
- ACM SIGKDD conferences since 1998 and SIGKDD Explorations
- More conferences on data mining
 - PAKDD (1997), PKDD (1997), SIAM-Data Mining (2001), (IEEE) ICDM (2001), WSDM (2008), etc.
- ACM Transactions on KDD (2007)

Conferences and Journals on Data Mining

- KDD Conferences
 - ACM SIGKDD Int. Conf. on Knowledge Discovery in Databases and Data Mining (**KDD**)
 - SIAM Data Mining Conf. (**SDM**)
 - (IEEE) Int. Conf. on Data Mining (**ICDM**)
 - European Conf. on Machine Learning and Principles and practices of Knowledge Discovery and Data Mining (**ECML-PKDD**)
 - Pacific-Asia Conf. on Knowledge Discovery and Data Mining (**PAKDD**)
 - Int. Conf. on Web Search and Data Mining (**WSDM**)
- Other related conferences
 - DB conferences: ACM SIGMOD, VLDB, ICDE, EDBT, ICDT, ...
 - Web and IR conferences: WWW, SIGIR, WSDM
 - ML conferences: ICML, NIPS
 - PR conferences: CVPR,
- Journals
 - Data Mining and Knowledge Discovery (DAMI or DMKD)
 - IEEE Trans. On Knowledge and Data Eng. (TKDE)
 - KDD Explorations
 - ACM Trans. on KDD


Where to Find References? DBLP, CiteSeer, Google

- Data mining and KDD (SIGKDD: CDROM)
 - Conferences: ACM-SIGKDD, IEEE-ICDM, SIAM-DM, PKDD, PAKDD, etc.
 - Journal: Data Mining and Knowledge Discovery, KDD Explorations, ACM TKDD
- Database systems (SIGMOD: ACM SIGMOD Anthology—CD ROM)
 - Conferences: ACM-SIGMOD, ACM-PODS, VLDB, IEEE-ICDE, EDBT, ICDT, DASFAA
 - Journals: IEEE-TKDE, ACM-TODS/TOIS, JIIS, J. ACM, VLDB J., Info. Sys., etc.
- AI & Machine Learning
 - Conferences: Machine learning (ML), AAAI, IJCAI, COLT (Learning Theory), CVPR, NIPS, etc.
 - Journals: Machine Learning, Artificial Intelligence, Knowledge and Information Systems, IEEE-PAMI, etc.
- Web and IR
 - Conferences: SIGIR, WWW, CIKM, etc.
 - Journals: WWW: Internet and Web Information Systems,
- Statistics
 - Conferences: Joint Stat. Meeting, etc.
 - Journals: Annals of statistics, etc.
- Visualization
 - Conference proceedings: CHI, ACM-SIGGraph, etc.
 - Journals: IEEE Trans. visualization and computer graphics, etc.

Recommended Reference Books

- **E. Alpaydin. Introduction to Machine Learning, 2nd ed., MIT Press, 2011**
- **S. Chakrabarti. Mining the Web: Statistical Analysis of Hypertext and Semi-Structured Data. Morgan Kaufmann, 2002**
- **R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification, 2ed., Wiley-Interscience, 2000**
- **T. Dasu and T. Johnson. Exploratory Data Mining and Data Cleaning. John Wiley & Sons, 2003**
- **U. M. Fayyad, G. Piatetsky-Shapiro, P. Smyth, and R. Uthurusamy. Advances in Knowledge Discovery and Data Mining. AAAI/MIT Press, 1996**
- **U. Fayyad, G. Grinstein, and A. Wierse, Information Visualization in Data Mining and Knowledge Discovery, Morgan Kaufmann, 2001**
- **J. Han and M. Kamber. Data Mining: Concepts and Techniques. Morgan Kaufmann, 2nd ed., 2006 (3ed. 2011)**
- **T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd ed., Springer-Verlag, 2009**
- **B. Liu, Web Data Mining, Springer 2006.**
- **T. M. Mitchell, Machine Learning, McGraw Hill, 1997**
- **P.-N. Tan, M. Steinbach and V. Kumar, Introduction to Data Mining, Wiley, 2005**
- **S. M. Weiss and N. Indurkha, Predictive Data Mining, Morgan Kaufmann, 1998**
- **I. H. Witten and E. Frank, Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan Kaufmann, 2nd ed. 2005**

Chapter 1. Introduction

- Why Data Mining?
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining
- What Kind of Data Can Be Mined?
- What Kinds of Patterns Can Be Mined?
- What Technology Are Used?
- What Kind of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary 

Summary

- Data mining: Discovering interesting patterns and knowledge from massive amount of data
- A natural evolution of science and information technology, in great demand, with wide applications
- A KDD process includes data cleaning, data integration, data selection, transformation, data mining, pattern evaluation, and knowledge presentation
- Mining can be performed in a variety of data
- Data mining functionalities: characterization, discrimination, association, classification, clustering, trend and outlier analysis, etc.
- Data mining technologies and applications
- Major issues in data mining

