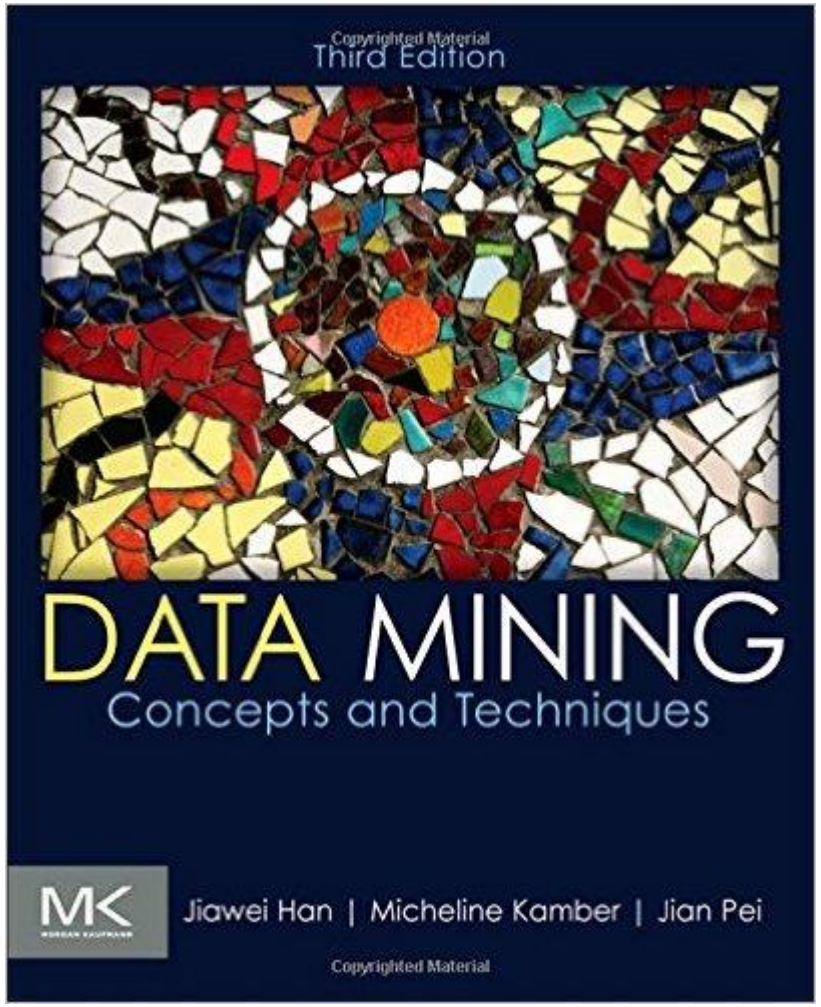
Data Warehouse & Data Mining

↳ หาสิ่งที่มีค่าที่อยู่ใน data

Chapter 1. Introduction

Jiawei Han, Computer Science, Univ. Illinois at Urbana-Champaign, 2017

CS 412. Course Page & Class Schedule



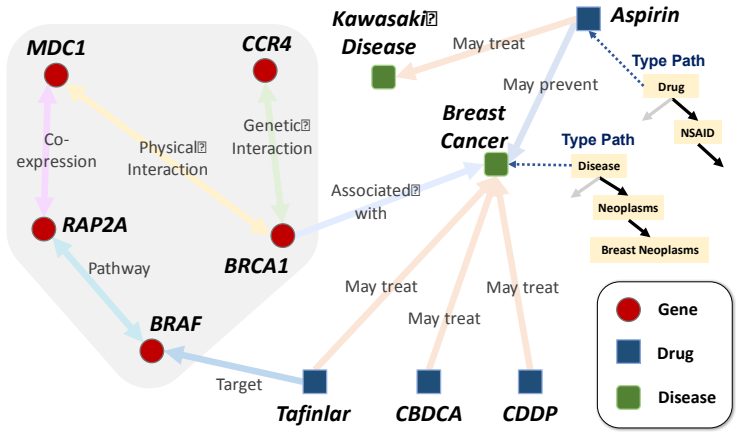
- Textbook
  - Jiawei Han, Micheline Kamber and Jian Pei, *Data Mining: Concepts and Techniques (3rd ed)*, Morgan Kaufmann, 2011
- Class Homepage: https://wiki.engr.illinois.edu/display/cs412
- Bookmark on course schedule page
- **Class Schedule: 9:30-10:45 am Tues./Thurs.@1404 SC**
- Office hours: 10:45-11:30am Tues./Thurs. @2132 SC
- Lecture media: recorded; but class attendance is critical

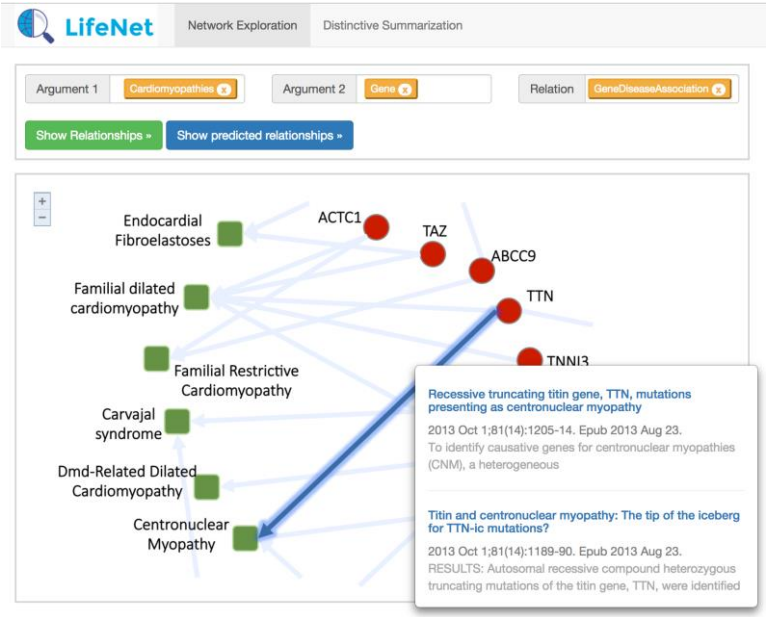
CS 412. Course Work and Grading

- Assignments, Programming Assignments, and Exams
  - Written Assignments: 15% (three homework assignments expected)
  - Programming assignments: 20% (two programming assignments expected)
  - Midterm exam: 30%
  - Final exam: 35%
- For students taking 4th credit (TA will provide concrete instructions on the 4th credit project)
  - For students registering 4 credits: 25%. The overall scores will be scaled proportionally
- Need help and/or discussions?
  - Sign on: Piazza (https://piazza.com/illinois/cs412)
- Check your homework/exam scores:
  - Compass

Help Needed: LifeNet—A Structured Network-Based Knowledge Exploration and Analytics System for Life Sciences

- What we are doing?
  - A scalable system that transforms biomedical papers into a knowledge graph & supports various search/analytics functions
- What we already have?
  - A working prototype system & an ACL demo paper
- What we are looking for?
  - Students with expertise on HTML/CSS & JavaScript
  - Experiences on web frameworks and databases
  - System design experience will be a big plus
- What you will gain?
  - Hourly pay ($12-$15 per hour, 6-20 hours per week)
  - Possible research publications & a good thesis topic





Send us your resume if interested: **Jiaming Shen** (mickeysjm@gmail.com)

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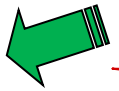
- Why Data Mining?  จะนำ data ที่มีอยู่ไปหาองค์ความรู้ได้อย่างไร
- What Is Data Mining?
- A Multi-Dimensional View of Data Mining หน้าตาของ data
- What Kinds of Data Can Be Mined? ชนิดของ data
- What Kinds of Patterns Can Be Mined?
- What Kinds of Technologies Are Used? มีเทคนิคหลักๆ ได้กี่แบบ
- What Kinds of Applications Are Targeted?
- Major Issues in Data Mining
- A Brief History of Data Mining and Data Mining Society
- Summary

data base → เรียนว่าจะเก็บข้อมูลยังไง
data mining → จะทำประโยชน์ต่อจากนั้น

Why Data Mining?

การทำเหมืองข้อมูล

- 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 → เก็บ data ได้หมด รู้หมดว่าใครเปิดดูเว็บบ้าง
- We are drowning in data, but starving for knowledge!
- "Necessity is the mother of invention"—Data mining—Automated analysis of massive data sets

ex. จัดหมู่ให้คนสามารถค้นหาได้ง่าย

ex. คนที่ดูเว็บไซต์ จ้องมองตรงไหนมากที่สุด อาจจะเอาโฆษณาไปวางไว้เพื่อให้คนสนใจ

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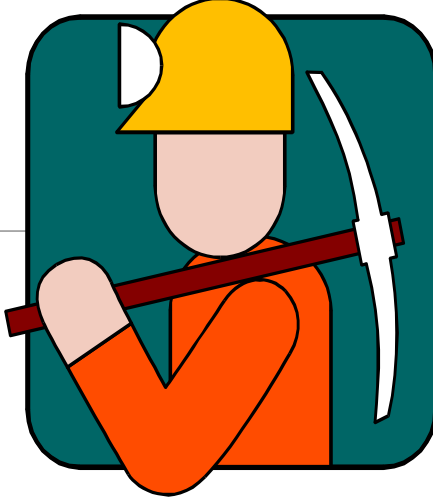
Web : https:data.go.th

What Is Data Mining?

การทำเหมืองข้อมูล → สกัดความรู้นั้น



- 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?

ชื่อเดิมมีอะไรบ้าง

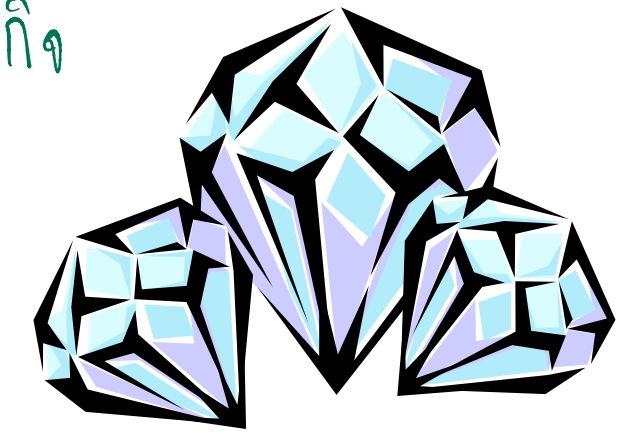
- Alternative names

การค้นพบองค์ความรู้ → จากฐานข้อมูลหลายๆแหล่ง

  - Knowledge discovery (mining) in databases (KDD), knowledge extraction, data/pattern analysis, data archeology, data dredging, information harvesting, business intelligence, etc.

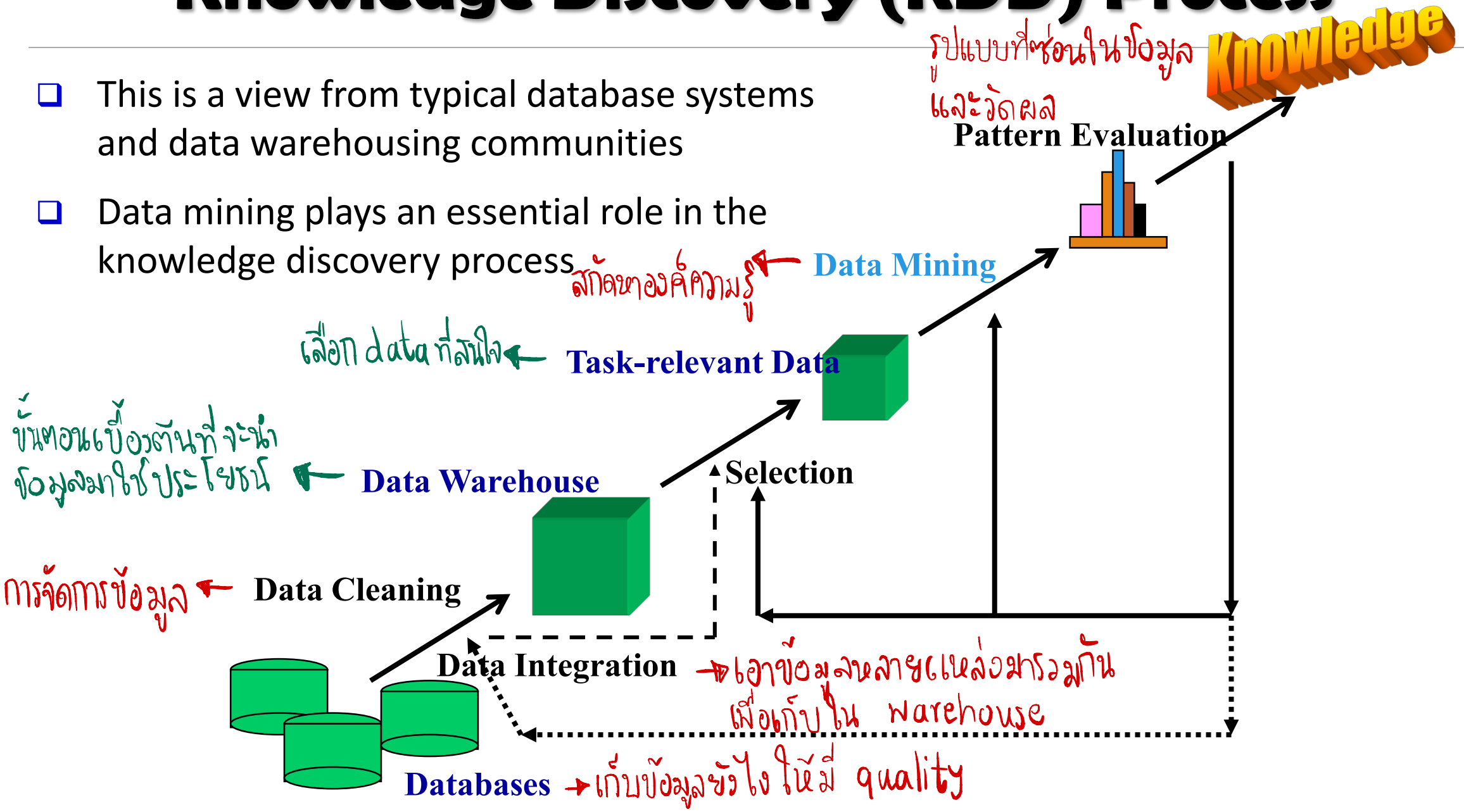
→ สกัดองค์ความรู้จาก data เพื่อตัดสินใจในธุรกิจ

- 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

อธิบายขั้นตอนการ Mining

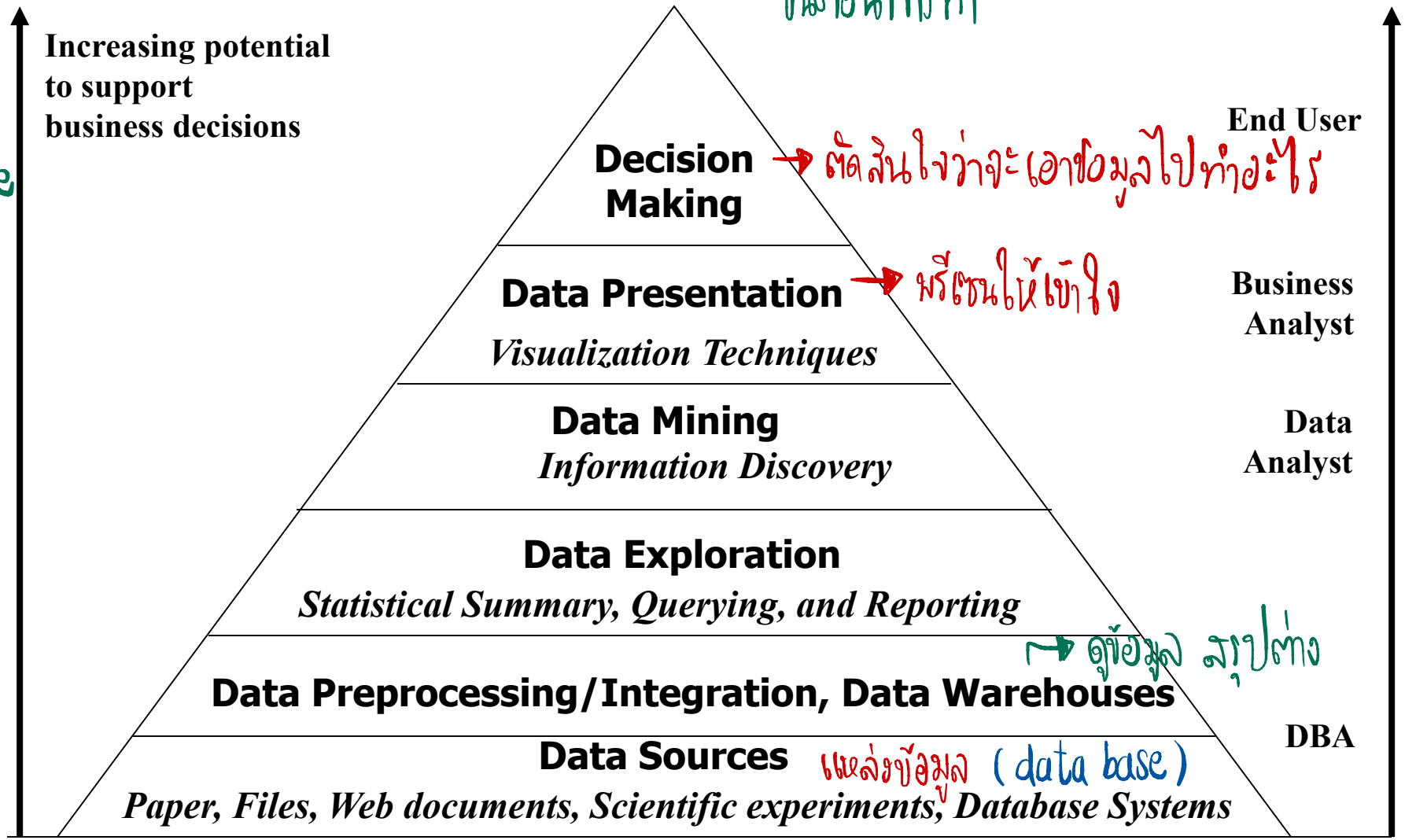
ทำ mining data ที่เป็น Web

- 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 นำองค์ความรู้ออกมาแสดงหรือนำเสนอ
  - Patterns and knowledge to be used or stored into knowledge-base

Mining ข้อมูลเพื่อตัดสินใจทางธุรกิจ

Data Mining in Business Intelligence

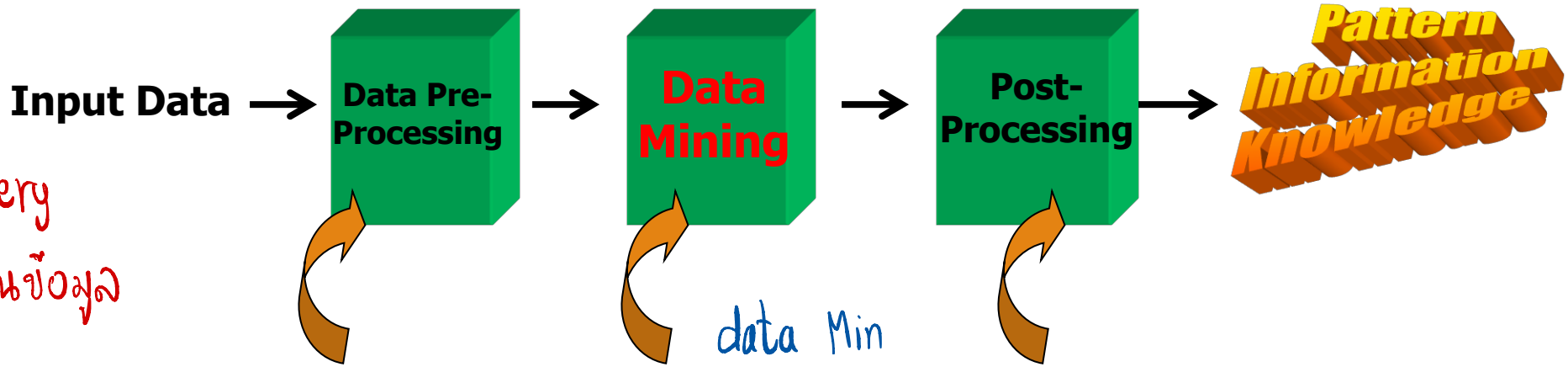
ขั้นตอนการทำ



Data Warehouse
⇒ เอา data ที่มีอยู่มารวมกัน จัดระเบียบให้ดูง่ายๆ

KDD Process: A View from ML and Statistics

นำ data เข้ามา



Pattern discovery
⇒หารูปแบบที่อยู่ในข้อมูล
classification
⇒ การจำแนกข้อมูล
clustering
⇒การแบ่งกลุ่ม

data Min

Data integration	Pattern discovery	Pattern evaluation
Normalization	Classification	Pattern selection
Feature selection	Clustering	Pattern interpretation
Dimension reduction	Outlier analysis	Pattern visualization
	... ...	

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

Data Mining vs. Data Exploration

- Which view do you prefer?
  - KDD vs. ML/Stat. vs. Business Intelligence
  - Depending on the data, applications, and your focus

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

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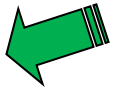
- A Multi-Dimensional View of Data Mining 
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Multi-Dimensional View of Data Mining

- **Data to be mined**
  - Database data (extended-relational, object-oriented, heterogeneous), 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, …
  - 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.

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How the data suppose to look like

หน้าตาของ data ที่เราจะจัดออกมา

↓ Columns: Attributes, Fields, Features: คำที่ใช้อธิบายคุณสมบัติของข้อมูล

	id	name	domain_id	closed	city_name	zipcode	geohash	new_open	weighted_average_rating	number_of_chains	...	good_for_groups
0	2	นครินทร์ ทันตกรรม	2	0	Samut Songkhram	75000	w4rh7g3	0	5.000000	NaN	...	NaN
1	4	Corner House	1	0	Bangkok Metropolitan Region	12150	w4rx73h	0	2.000000	NaN	...	NaN
2	5	วัดโลกยสุธาราม	4	0	Phra Nakhon Si Ayutthaya	13000	w4x98jk	0	4.000000	NaN	...	NaN
3	6	นันทน์คาราโอเกะ	1	0	Bangkok Metropolitan Region	10700.0	w4rqw9q	0	0.000000	NaN	...	NaN
4	7	Buono Caffe	1	0	Bangkok Metropolitan	10220	w4rx4gd	0	3.738462	NaN	...	NaN

→ Rows: Records, Data point: ข้อมูลแต่ละตัว

Data Mining: On What Kinds of Data?

- Database-oriented data sets and applications
  - Relational database, data warehouse, transactional database
  - Object-relational databases, Heterogeneous databases and legacy databases
- 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 information networks
  - Spatial data and spatiotemporal data
  - Multimedia database
  - Text databases
  - The World-Wide Web

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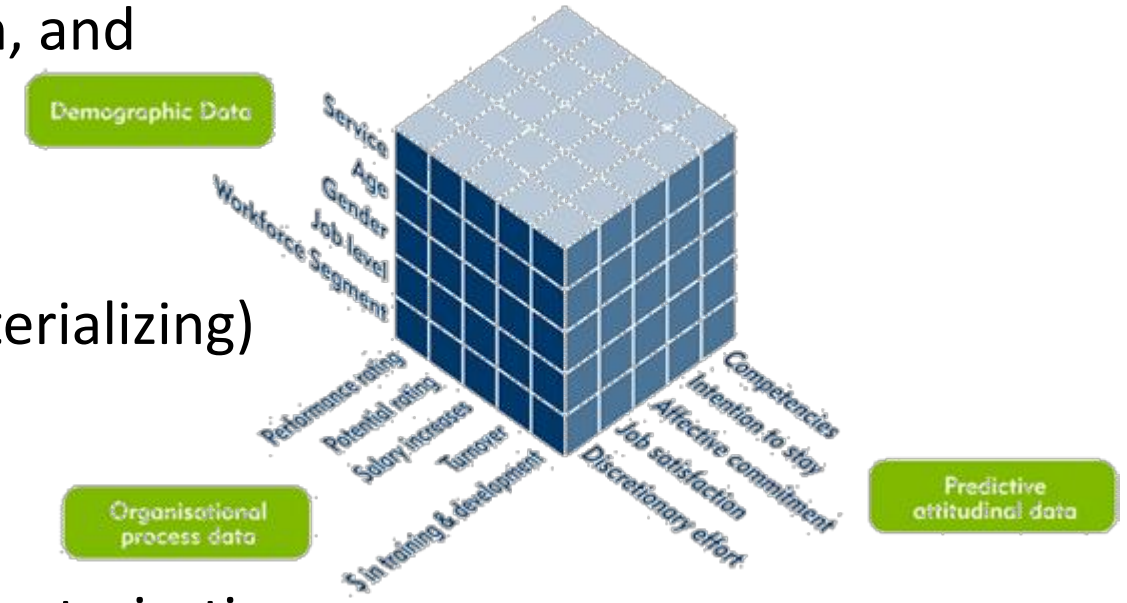
Data Mining Functions: (1) Generalization

- 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

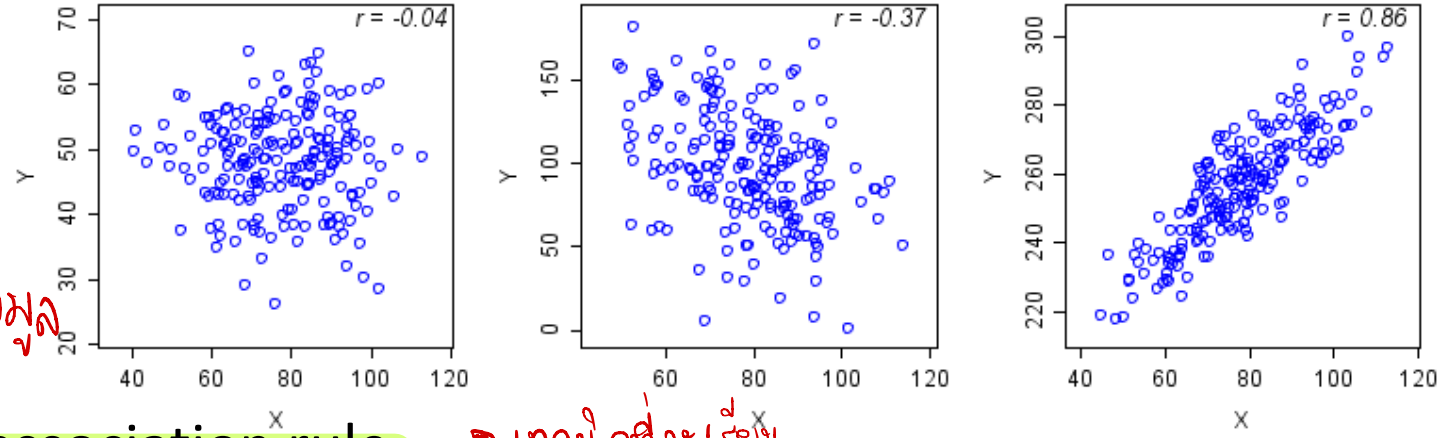


เทคนิคของ data mining ที่จะเรียน

1. การสกัดหารูปแบบที่เกิดขึ้นซ้ำในข้อมูล

Data Mining Functions: (2) Pattern Discovery

- Frequent patterns (or frequent itemsets)
  - What items are frequently purchased together in your Walmart?
- Association and Correlation Analysis



หา Pattern ที่เกิดขึ้นในข้อมูล

- A typical association rule → เทคนิคที่จะเรียน
  - Diaper → Beer [0.5%, 75%] (support, confidence)

ผ้าอ้อม เบียร์ จะเกิดขึ้นมาก

ใช้วิเคราะห์ใบเสร็จของคนที่มา shopping → คนที่ซื้อผ้าอ้อมมักจะซื้อเบียร์ด้วย

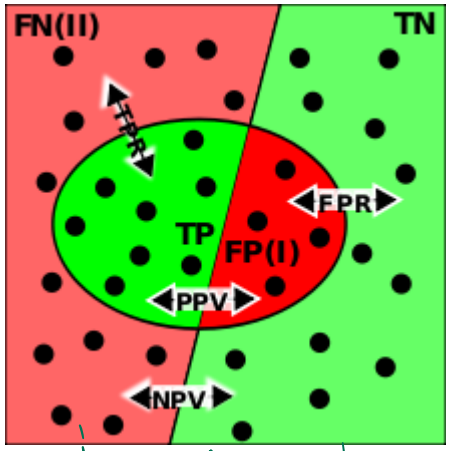
  - Are strongly associated items also strongly correlated?
- How to mine such patterns and rules efficiently in large datasets?
- How to use such patterns for classification, clustering, and other applications?

Data Mining Functions: (3) Classification

2. การจำแนกกลุ่ม

ใช้ข้อมูลที่มีอยู่เพื่อทำนาย class

- Classification and label prediction ex. ข้อมูลของกรมอุตุ เลือก 1 Attributes มาเป็น y (ค่าทำนาย)
  - Construct models (functions) based on some training examples
  - Describe and distinguish classes or concepts for future prediction
    - Ex. 1. Classify countries based on (climate)
    - Ex. 2. Classify cars based on (gas mileage)
  - Predict some unknown class labels



- ใช้ Attributes ต่างๆ เพื่อทำนาย Attributes ที่เหลืออีกตัวหนึ่งของ Records เดียวกันหรือถัดไป
- Typical methods
  - Decision trees, naïve Bayesian classification, support vector machines, neural networks, rule-based classification, pattern-based classification, logistic regression, …

ทำนายค่าที่ไม่ใช่ตัวเลข มีค่า y ทำนาย

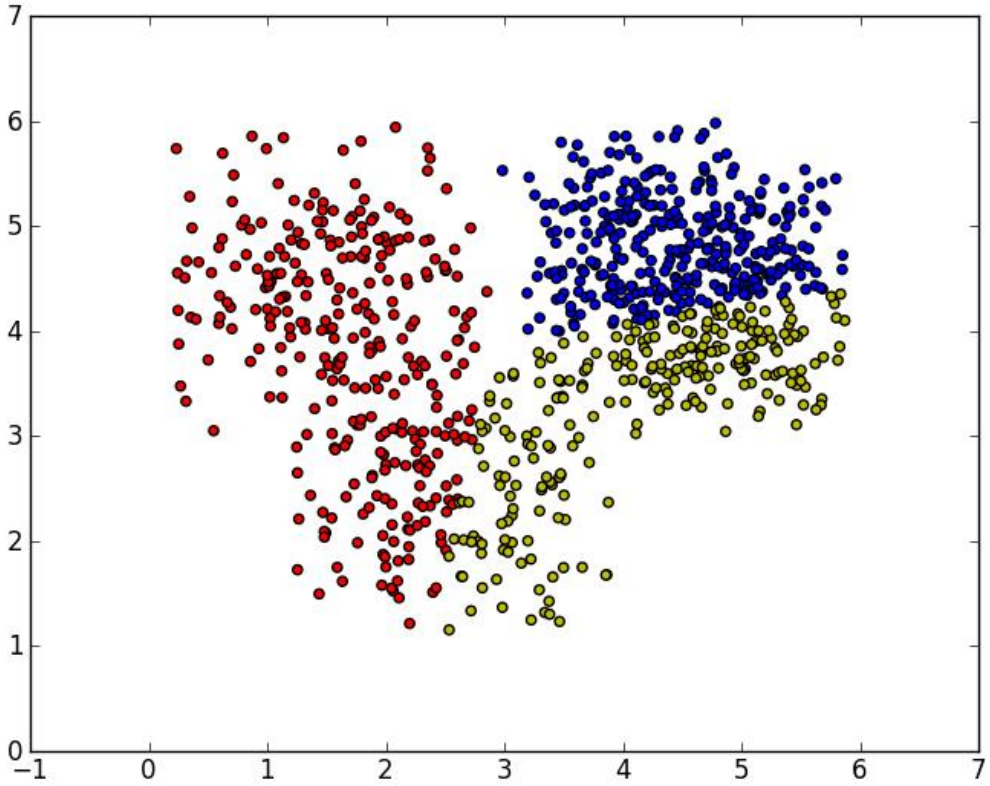
- Typical applications:
  - Credit card fraud detection, direct marketing, classifying stars, diseases, web-pages, …

Data Mining Functions: (4) Cluster Analysis

3. การแบ่งกลุ่ม
ไม่มีคำตอบให้ทำนาย

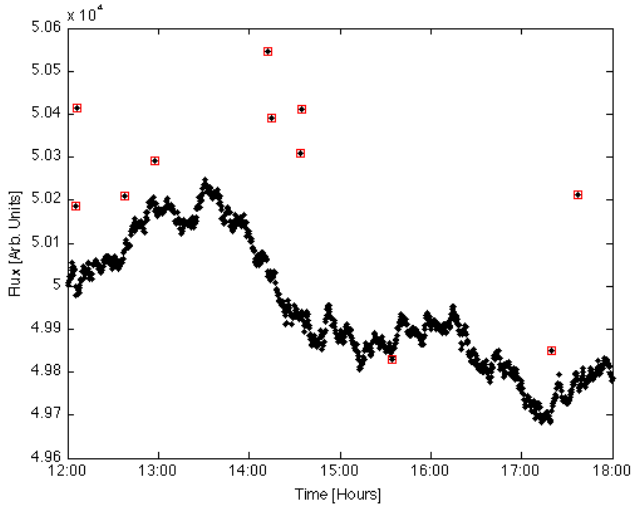
- จะดูว่าจะจับกลุ่ม Records ยังไง

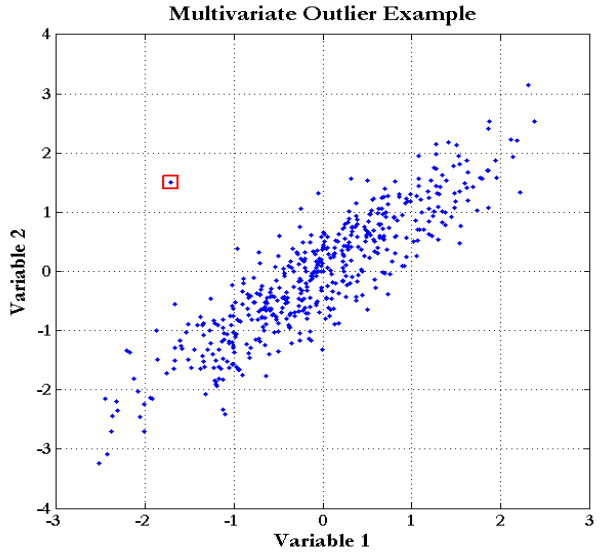
- Unsupervised learning (i.e., Class label is unknown)
- Group data to form new categories (i.e., clusters), e.g., cluster houses to find distribution patterns
- Principle: Maximizing intra-class similarity & minimizing interclass similarity
- Many methods and applications



Data Mining Functions: (5) Outlier Analysis

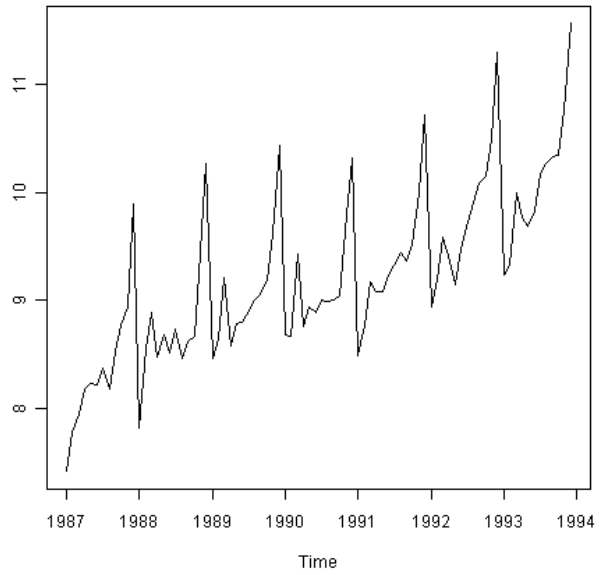
- Outlier analysis
  - Outlier: A data object that does not comply with the general behavior of the data
  - Noise or exception?—One person's garbage could be another person's treasure
  - Methods: by product of clustering or regression analysis, …
  - Useful in fraud detection, rare events analysis





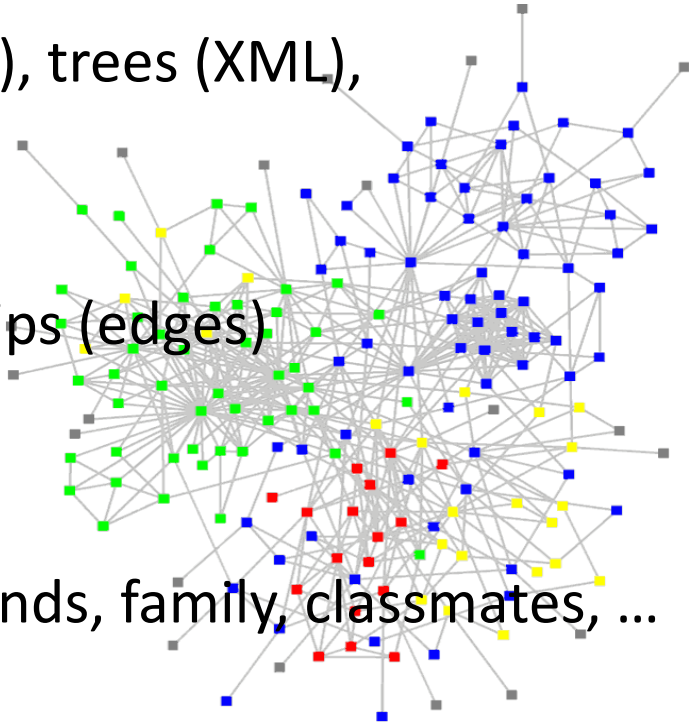
Data Mining Functions: (6) Time and Ordering: Sequential Pattern, Trend and Evolution Analysis

- Sequence, trend and evolution analysis
  - Trend, time-series, and deviation analysis
    - e.g., regression and value prediction
  - Sequential pattern mining
    - e.g., buy digital camera, then buy large 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



Data Mining Functions: (7) 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"
  - 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
  - …

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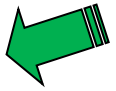
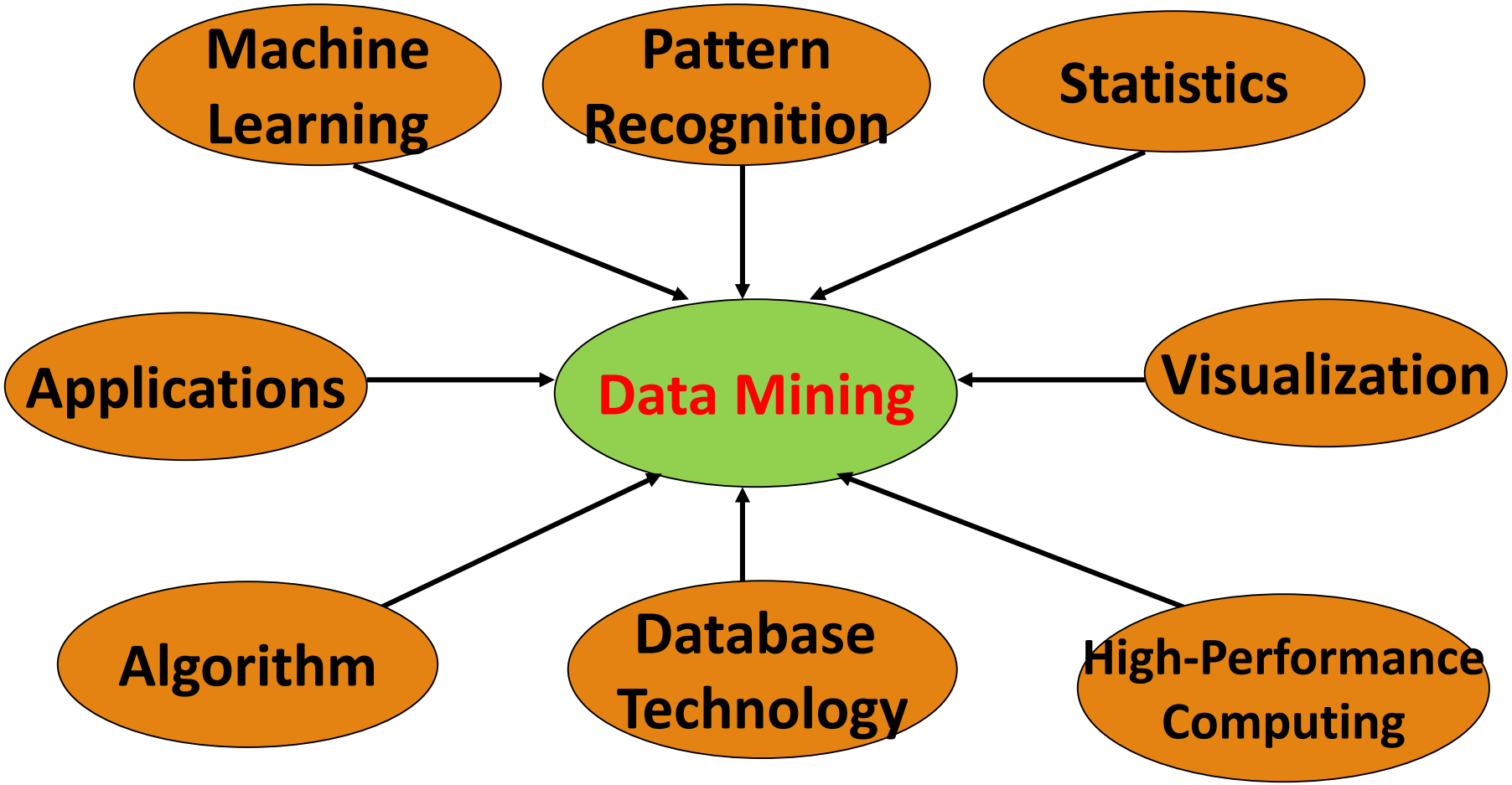


Data Mining: Confluence of Multiple Disciplines



Why Confluence of Multiple Disciplines?

- Tremendous amount of data
  - Algorithms must be scalable to handle big 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 and information networks
  - Spatial, spatiotemporal, multimedia, text and Web data
  - Software programs, scientific simulations
- New and sophisticated applications

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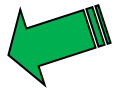
- What Kinds of Applications Are Targeted? 
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Applications of Data Mining

- Web page analysis: classification, clustering, ranking
- Collaborative analysis & recommender systems
- Basket data analysis to targeted marketing
- Biological and medical data analysis
- Data mining and software engineering
- Data mining and text analysis
- Data mining and social and information network analysis
- Built-in (invisible data mining) functions in Google, MS, Yahoo!, Linked, Facebook, …
- Major dedicated data mining systems/tools
  - SAS, MS SQL-Server Analysis Manager, Oracle Data Mining Tools)

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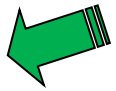
- Major Issues in Data Mining 
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Major Issues in Data Mining (1)

- 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

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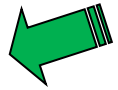
- A Brief History of Data Mining and Data Mining Society 
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A Brief History of Data Mining Society

- 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)
  - Conferences: ACM-SIGKDD, IEEE-ICDM, SIAM-DM, PKDD, PAKDD, etc.
  - Journal: Data Mining and Knowledge Discovery, KDD Explorations, ACM TKDD
- Database systems (SIGMOD)
  - 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.

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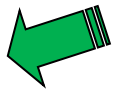
- Summary 

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

Recommended Reference Books

- Charu C. Aggarwal, Data Mining: The Textbook, Springer, 2015
- E. Alpaydin. Introduction to Machine Learning, 2nd ed., MIT Press, 2011
- R. O. Duda, P. E. Hart, and D. G. Stork, Pattern Classification, 2ed., Wiley-Interscience, 2000
- U. Fayyad, G. Grinstein, and A. Wierse, Information Visualization in Data Mining and Knowledge Discovery, Morgan Kaufmann, 2001
- J. Han, M. Kamber, and J. Pei, Data Mining: Concepts and Techniques. Morgan Kaufmann, 3rd ed. , 2011
- T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd ed., Springer, 2009
- T. M. Mitchell, Machine Learning, McGraw Hill, 1997
- P.-N. Tan, M. Steinbach and V. Kumar, Introduction to Data Mining, Wiley, 2005 (2nd ed. 2016)
- I. H. Witten and E. Frank, Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan Kaufmann, 2nd ed. 2005
- Mohammed J. Zaki and Wagner Meira Jr., Data Mining and Analysis: Fundamental Concepts and Algorithms 2014