Module 1: Machine Learning, Data Mining, and Knowledge Discovery: An Introduction

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Course : Data Mining

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IICT, University of Sindh

Courtesy : Gregory Piatetsky-Shapiro/KDnuggets

Course Outline

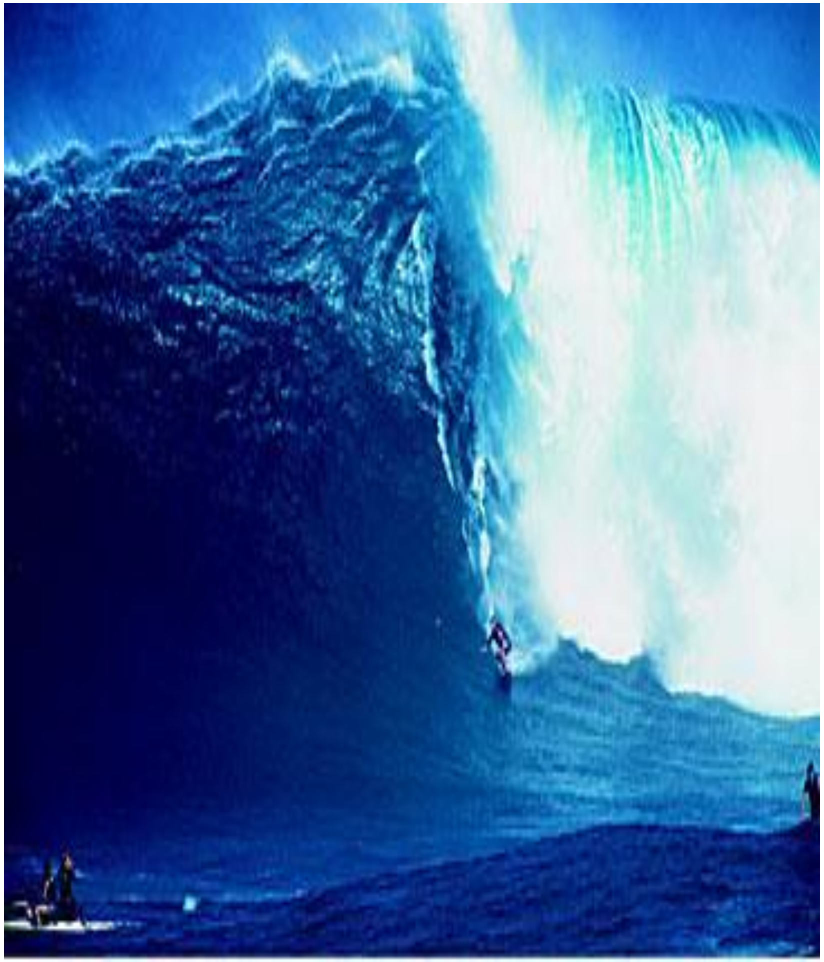
- Machine Learning
  - input, representation, decision trees
- Weka
  - machine learning workbench
- Data Mining
  - associations, deviation detection, clustering, visualization
- Case Studies
  - targeted marketing, genomic microarrays
  - Data Mining, Privacy and Security
- Final Project: Microarray Data Mining Competition

Lesson Outline

- **Introduction: Data Flood**
- Data Mining Application Examples
- Data Mining & Knowledge Discovery
- Data Mining Tasks

Trends leading to Data Flood

- More data is generated:
  - Bank, telecom, other business transactions ...
  - Scientific data: astronomy, biology, etc
  - Web, text, and e-commerce



Big Data Examples

- Europe's Very Long Baseline Interferometry (*Interference of waves*) (VLBI) has 16 telescopes, each of which produces **1 Gigabit/second** of astronomical data over a 25-day observation session
    - storage and analysis a big problem
- AT&T handles billions of calls per day
    - so much data, it cannot be all stored -- analysis has to be done “on the fly”, on streaming data

Largest databases in 2003

- Commercial databases:
  - Winter Corp. 2003 Survey: France Telecom has largest decision-support DB, ~30TB; AT&T ~ 26 TB
- Web
  - Alexa internet archive: 7 years of data, 500 TB
  - Google searches 4+ Billion pages, many hundreds TB
  - IBM WebFountain, 160 TB (2003)
  - Internet Archive (www.archive.org),~ 300 TB

From terabytes to exabytes to …

- UC Berkeley 2003 estimate: 5 exabytes (5 million terabytes) of new data was created in 2002.

www.sims.berkeley.edu/research/projects/how-much-info-2003/

- US produces ~40% of new stored data worldwide
- 2006 estimate: 161 exabytes (IDC study)
  - www.usatoday.com/tech/news/2007-03-05-data_N.htm
- 2010 projection: 988 exabytes

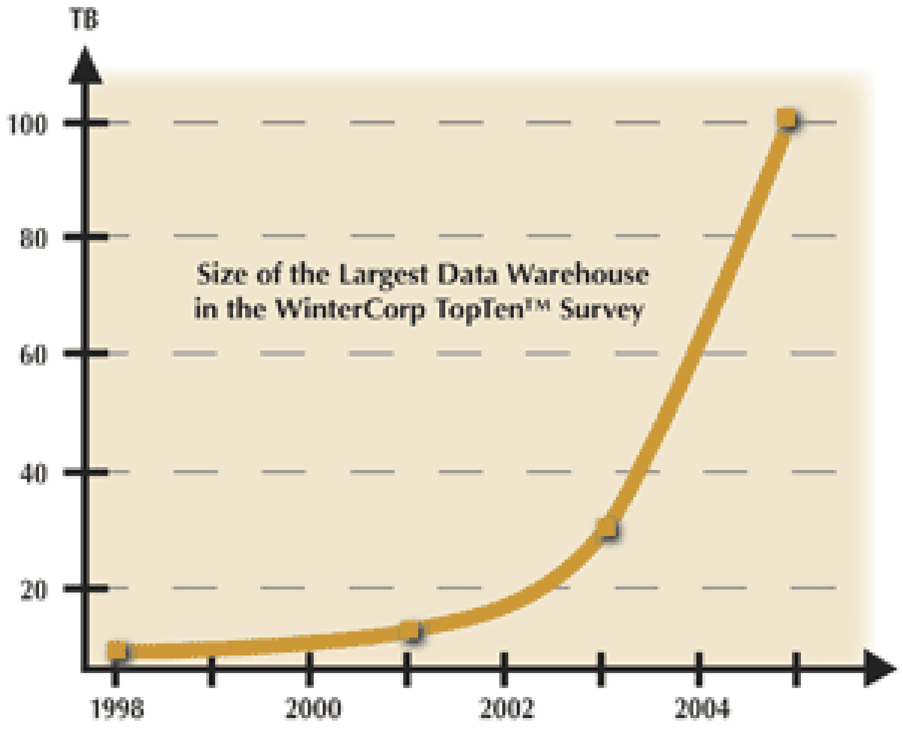
Largest Databases in 2005

Winter Corp. 2005 Commercial Database Survey:

1. Max Planck Inst. for Meteorology , 222 TB
2. Yahoo ~ 100 TB (Largest Data Warehouse)
3. AT&T ~ 94 TB

www.wintercorp.com/VLDB/2005_TopTen_Survey/TopTenWinners_2005.asp

Data Growth



In 2 years, the size of the largest database TRIPLED!

Data Growth Rate

- Twice as much information was created in 2002 as in 1999 (~30% growth rate)
- Other growth rate estimates even higher
- Very little data will ever be looked at by a human

Knowledge Discovery is **NEEDED** to make sense and use of data.

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Machine Learning / Data Mining Application areas

- Science
  - astronomy, bioinformatics, drug discovery, …
- Business
  - CRM (Customer Relationship management), fraud detection, e-commerce, manufacturing, sports/entertainment, telecom, targeted marketing, health care, …
- Web:
  - search engines, advertising, web and text mining, …
- Government
  - surveillance (?|), crime detection, profiling tax cheaters, …

Application Areas

What do you think are some of the most important and widespread business applications of Data Mining?

Data Mining for Customer Modeling

- Customer Tasks:
  - attrition prediction
  - targeted marketing:
    - cross-sell, customer acquisition
  - credit-risk
  - fraud detection
- Industries
  - banking, telecom, retail sales, …

Customer Attrition: Case Study

- Situation: Attrition rate at for mobile phone customers is around 25-30% a year!
- With this in mind, what is our task?
  - Assume we have customer information for the past N months.

Customer Attrition: Case Study

Task:

- Predict who is likely to attrite next month.
- Estimate customer value and what is the cost-effective offer to be made to this customer.

Customer Attrition Results

- Verizon Wireless built a customer data warehouse
- Identified potential attriters
- Developed multiple, regional models
- Targeted customers with high propensity to accept the offer
- Reduced attrition rate from over 2%/month to under 1.5%/month (huge impact, with >30 M subscribers)

(Reported in 2003)

Assessing Credit Risk: Case Study

- Situation: Person applies for a loan
- Task: Should a bank approve the loan?
- Note: People who have the best credit don't need the loans, and people with worst credit are not likely to repay. Bank's best customers are in the middle

Credit Risk - Results

- Banks develop credit models using variety of machine learning methods.
- Mortgage and credit card proliferation are the results of being able to successfully predict if a person is likely to default on a loan
- Widely deployed in many countries

e-commerce

- A person buys a book (product) at Amazon.com

What is the task?

Successful e-commerce – Case Study

- Task: Recommend other books (products) this person is likely to buy
- Amazon does clustering based on books bought:
  - customers who bought "**Advances in Knowledge Discovery and Data Mining**", also bought "**Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations**"
- Recommendation program is quite successful

Unsuccessful e-commerce case study (KDD-Cup 2000)

- Data: clickstream and purchase data from Gazelle.com, legwear and legcare e-tailer
- Q: Characterize visitors who spend more than $12 on an average order at the site
- Dataset of 3,465 purchases, 1,831 customers
- Very interesting analysis by Cup participants
  - thousands of hours - $X,000,000 (Millions) of consulting
- Total sales -- $Y,000
- Obituary: Gazelle.com out of business, Aug 2000

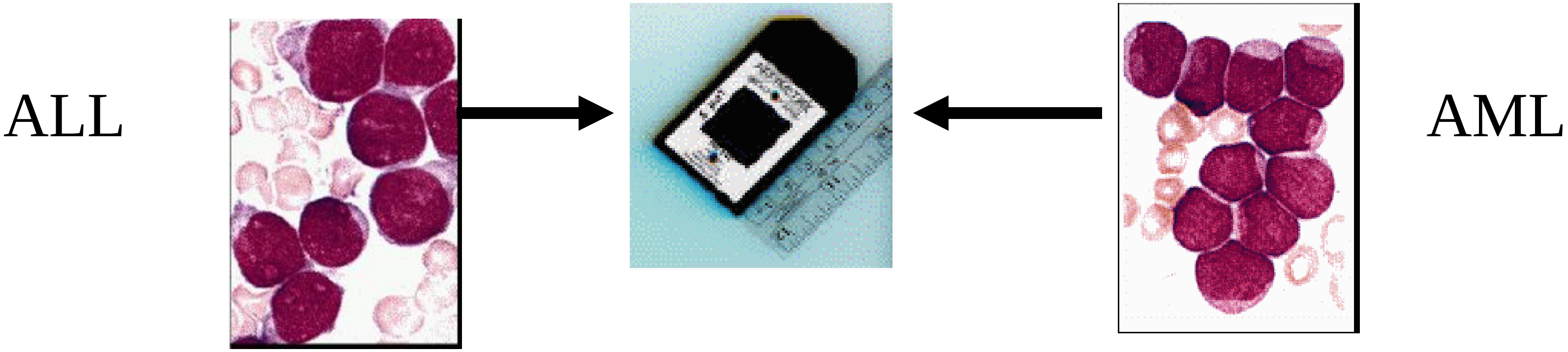
Genomic Microarrays – Case Study

Given microarray data for a number of samples (patients), can we

- Accurately diagnose the disease?
- Predict outcome for given treatment?
- Recommend best treatment?

Example: ALL/AML data

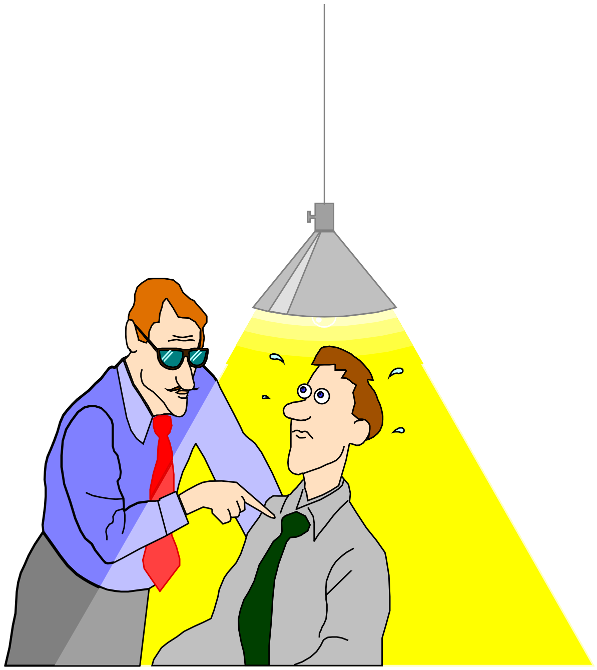
- 38 training cases, 34 test, ~ 7,000 genes
- 2 Classes: Acute Lymphoblastic Leukemia (ALL) vs Acute Myeloid Leukemia (AML)
- Use train data to build diagnostic model



Results on test data:
33/34 correct, 1 error may be mislabeled

Security and Fraud Detection - Case Study

- Credit Card Fraud Detection
- Detection of Money laundering
  - FAIS (US Treasury)
- Securities Fraud
  - NASDAQ KDD system
- Phone fraud
  - AT&T, Bell Atlantic, British Telecom/MCI
- Bio-terrorism detection at Salt Lake Olympics 2002



Data Mining and Privacy

- in 2006, NSA (National Security Agency) was reported to be mining years of call info, to identify terrorism networks
- Social network analysis has a potential to find networks
- Invasion of privacy – do you mind if your call information is in a gov database?
- What if NSA program finds one real suspect for 1,000 false leads ? 1,000,000 false leads?

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Knowledge Discovery Definition

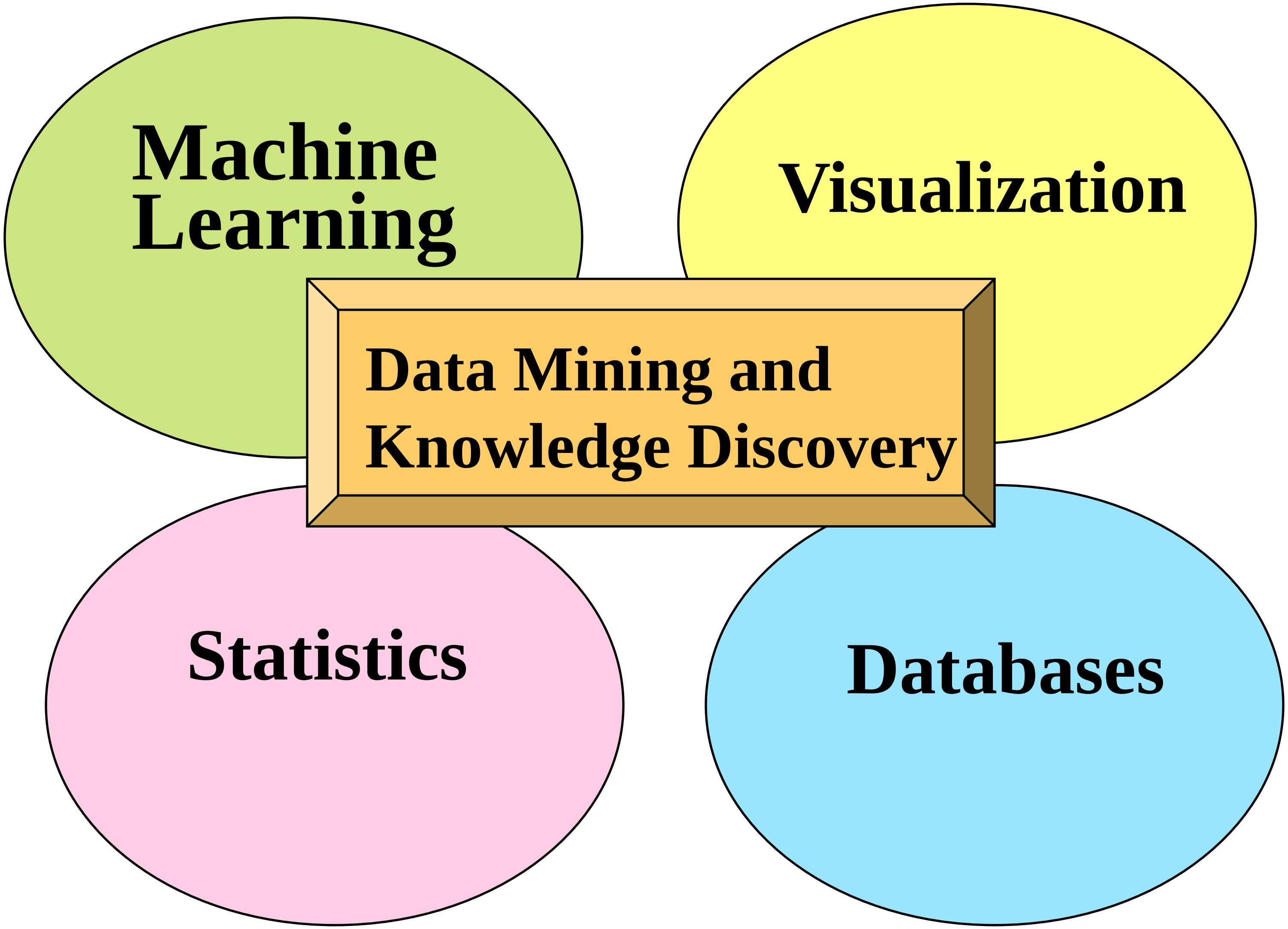
Knowledge Discovery in Data is the

non-trivial process of identifying

- *valid*
- *novel*
- potentially *useful*
- and ultimately *understandable patterns* in data.

from *Advances in Knowledge Discovery and Data Mining,* Fayyad, Piatetsky-Shapiro, Smyth, and Uthurusamy, (Chapter 1), AAAI/MIT Press 1996

Related Fields



Machine Learning

Visualization

Data Mining and Knowledge Discovery

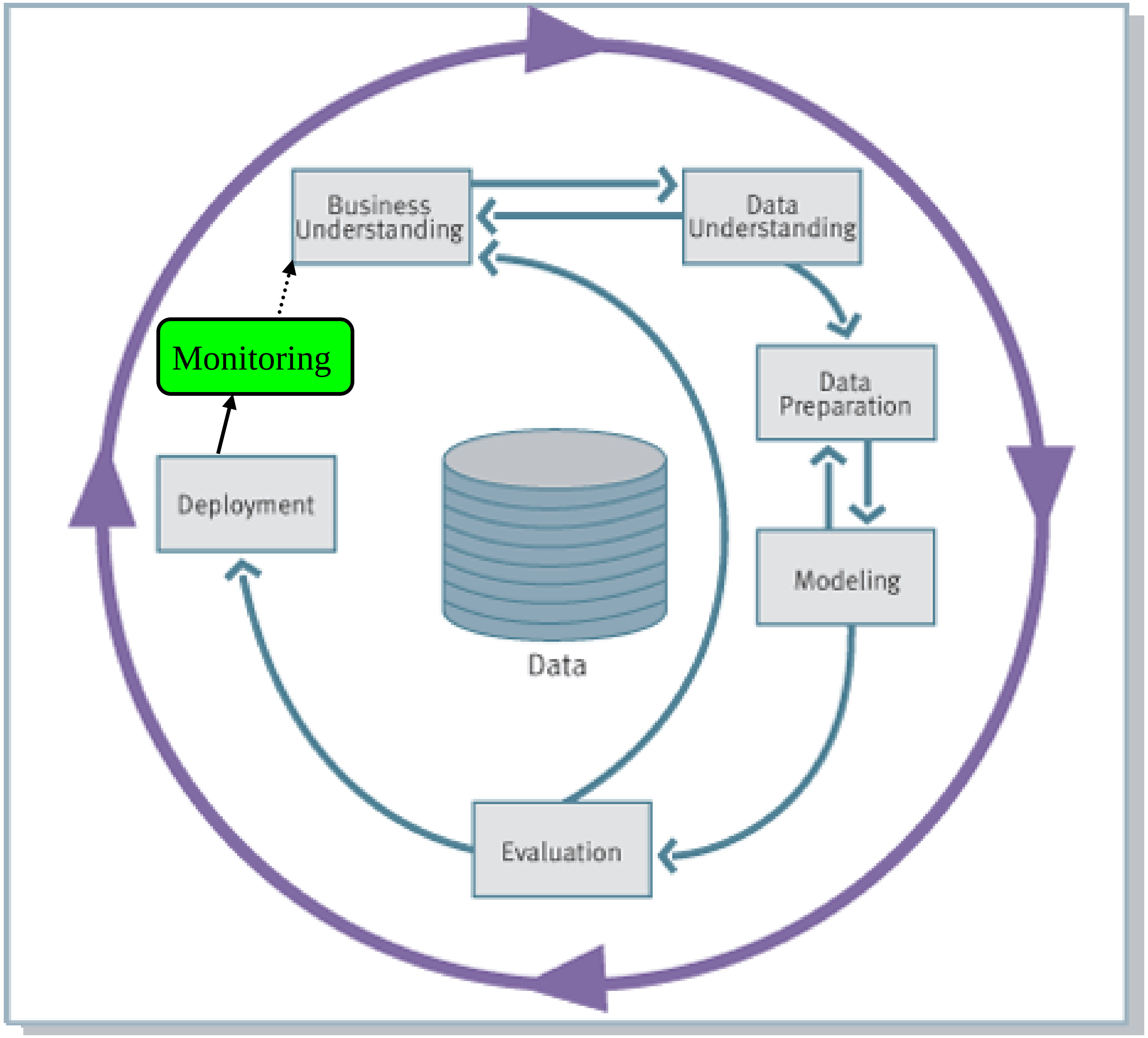
Statistics

Databases

Statistics, Machine Learning and Data Mining

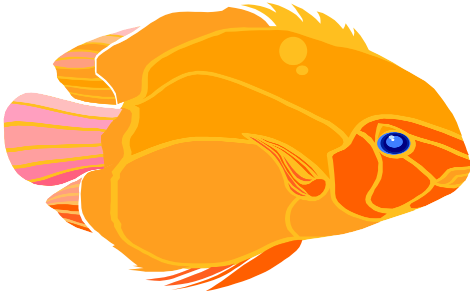
- Statistics:
  - more theory-based
  - more focused on testing hypotheses
- Machine learning
  - more heuristic
  - focused on improving performance of a learning agent
  - also looks at real-time learning and robotics – areas not part of data mining
- Data Mining and Knowledge Discovery
  - integrates theory and heuristics
  - focus on the entire process of knowledge discovery, including data cleaning, learning, and integration and visualization of results
- Distinctions are fuzzy

Knowledge Discovery Process flow, according to CRISP-DM



see www.crisp-dm.org for more information

Historical Note: Many Names of Data Mining



- Data Fishing, Data Dredging: 1960-
  - used by Statistician (as bad name)
- Data Mining :1990 --
  - used DB, business
  - in 2003 – bad image because of TIA
- Knowledge Discovery in Databases (1989-)
  - used by AI, Machine Learning Community
- also Data Archaeology, Information Harvesting, Information Discovery, Knowledge Extraction, ...

Currently: Data Mining and Knowledge Discovery are used interchangeably

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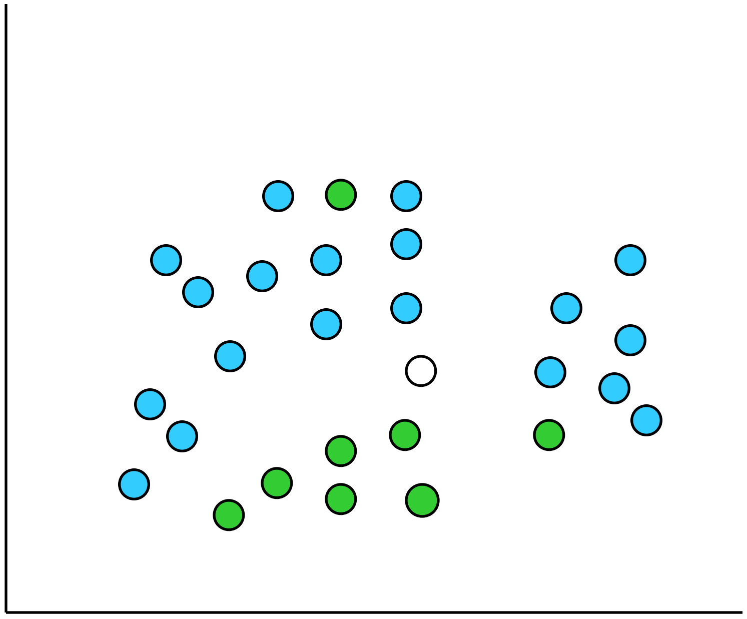
Major Data Mining Tasks

- **Classification:** predicting an item class
- **Clustering:** finding clusters in data
- **Associations:** e.g. A & B & C occur frequently
- **Visualization:** to facilitate human discovery
- **Summarization:** describing a group
- **Deviation Detection**: finding changes
- Estimation: predicting a continuous value
- Link Analysis: finding relationships
- …

Data Mining Tasks: Classification

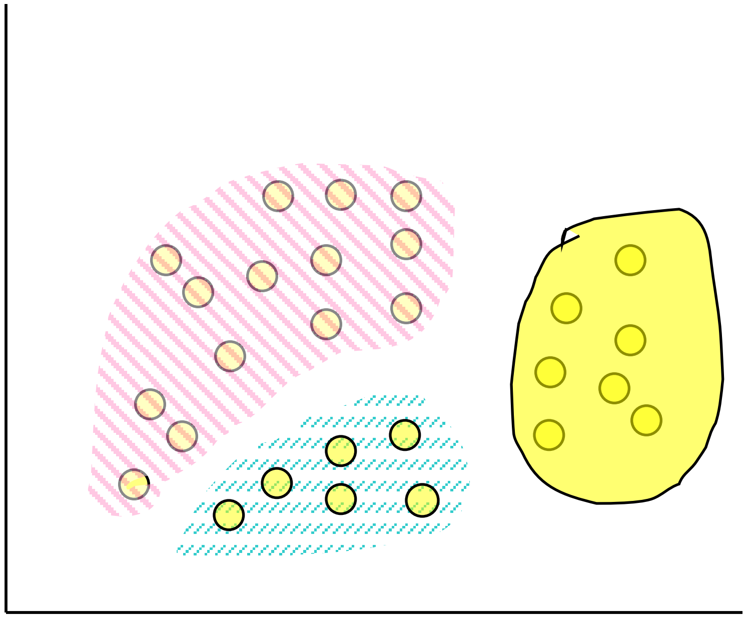
Learn a method for predicting the instance class from pre-labeled (classified) instances



Many approaches:
Statistics,
Decision Trees,
Neural Networks,
...

Data Mining Tasks: Clustering

Find "natural" grouping of instances given un-labeled data



Summary:

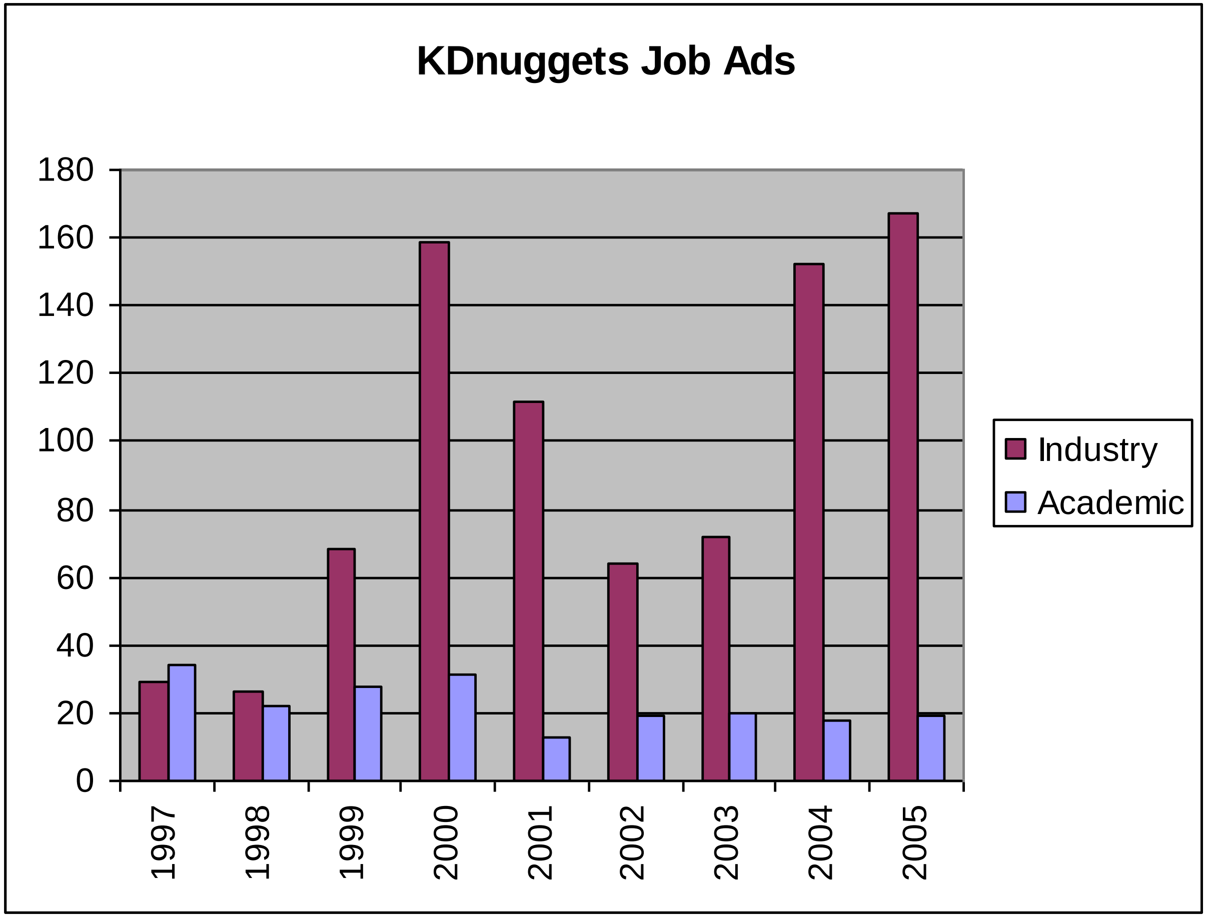
- Technology trends lead to data flood
  - data mining is needed to make sense of data
- Data Mining has many applications, successful and not
- Knowledge Discovery Process
- Data Mining Tasks
  - classification, clustering, …

More on Data Mining and Knowledge Discovery

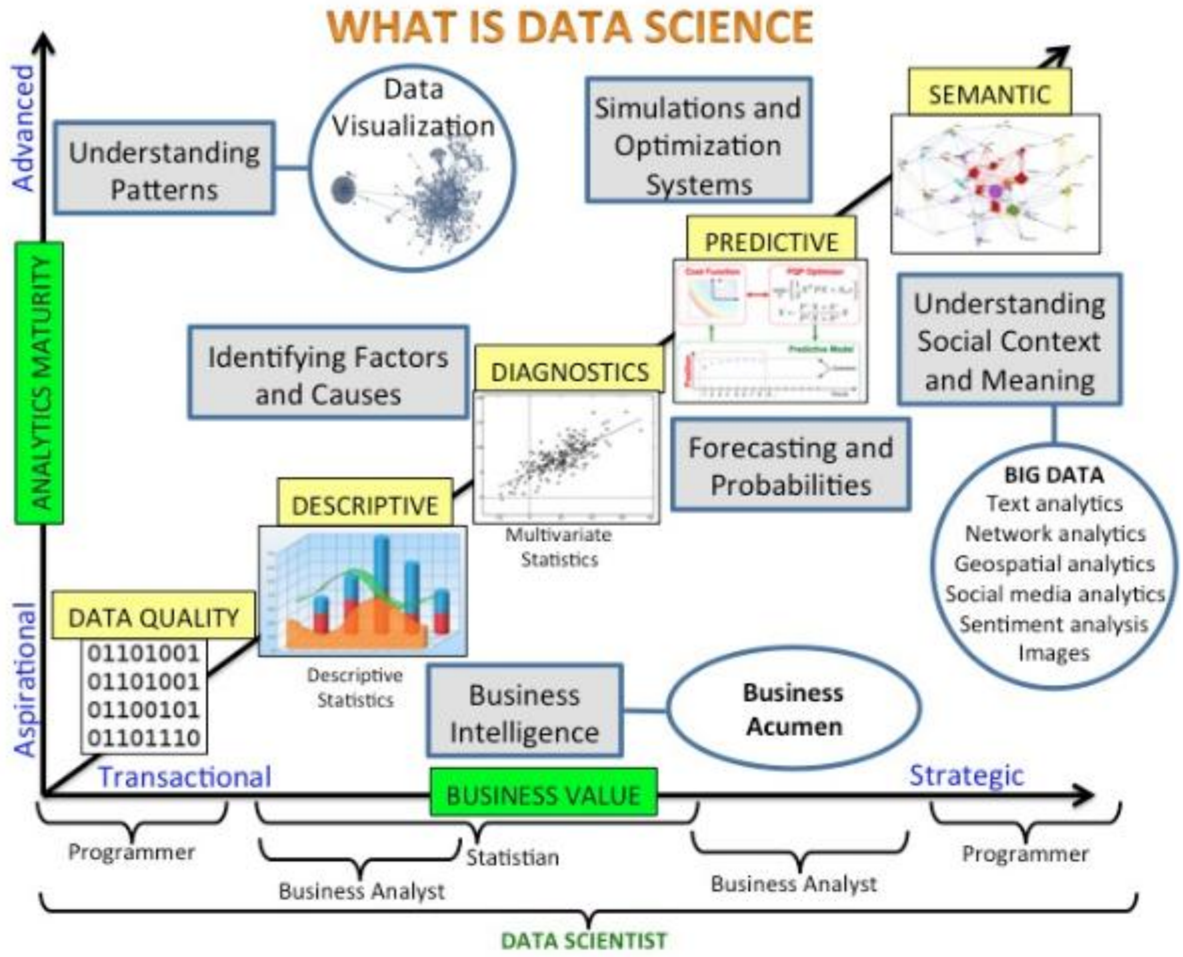
KDnuggets.com

- News, Publications
- Software, Solutions
- Courses, Meetings, Education
- Publications, Websites, Datasets
- Companies, Jobs
- …

Data Mining Jobs in KDnuggets



Data Science in one Picture



WHAT IS DATA SCIENCE

Advanced

ANALYTICS MATURITY

Aspirational

Understanding Patterns

Data Visualization

Simulations and Optimization Systems

SEMANTIC

PREDICTIVE

Understanding Social Context and Meaning

Identifying Factors and Causes

DIAGNOSTICS

Multivariate Statistics

Forecasting and Probabilities

BIG DATA
Text analytics
Network analytics
Geospatial analytics
Social media analytics
Sentiment analysis
Images

DESCRIPTIVE

Descriptive Statistics

DATA QUALITY

01101001
01101001
01100101
01101110

Business Intelligence

Business Acumen

Transactional

BUSINESS VALUE

Strategic

Programmer

Statistian

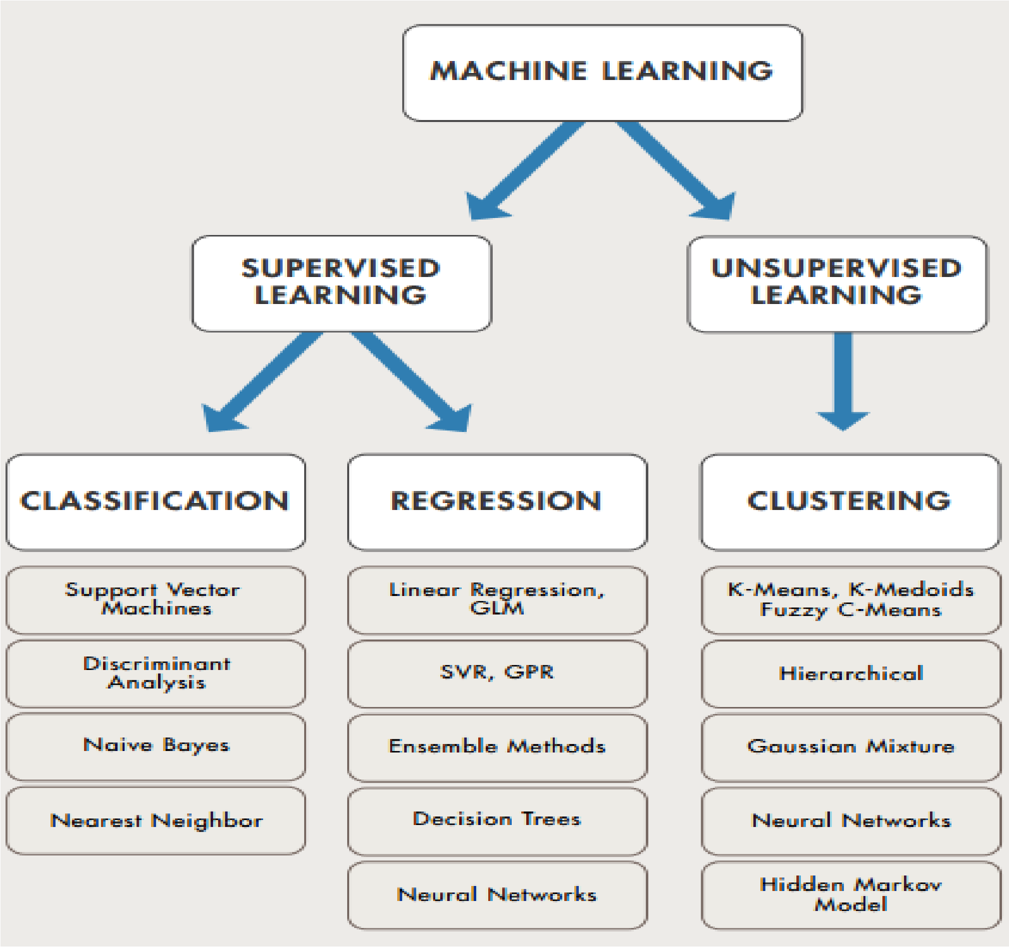
Business Analyst

Business Analyst

Programmer

DATA SCIENTIST

Machine Learning in one Picture


MACHINE LEARNING
SUPERVISED LEARNING
UNSUPERVISED LEARNING
CLASSIFICATION
REGRESSION
CLUSTERING
Support Vector Machines
Discriminant Analysis
Naive Bayes
Nearest Neighbor
Linear Regression, GLM
SVR, GPR
Ensemble Methods
Decision Trees
Neural Networks
K-Means, K-Medoids Fuzzy C-Means
Hierarchical
Gaussian Mixture
Neural Networks
Hidden Markov Model