Data Mining: Introduction

Lecture Notes for Chapter 1

Introduction to Data Mining, 2nd Edition

by

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OBJ

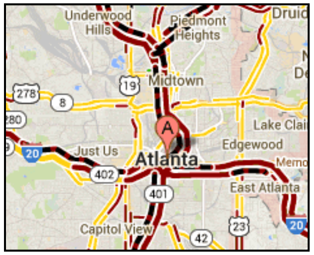
- เข้าใจที่มาของข้อมูลขนาดใหญ่
- อธิบายความจำเป็นของ Data Mining
- แยก “อะไรคือ/ไม่ใช่” Data Mining ได้
- เข้าใจ 6 งานหลักของ Data Mining
- อธิบายปัญหาและความท้าทายของข้อมูลยุคใหม่ได้

Large-scale Data is Everywhere!

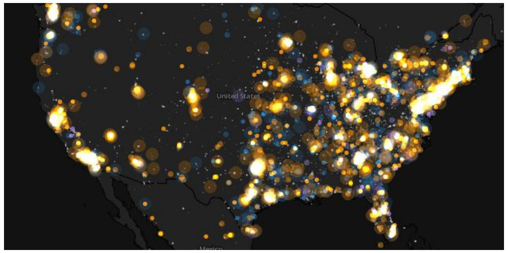
- There has been enormous data growth in both commercial and scientific databases due to advances in data generation and collection technologies
- New mantra
  - "Gather whatever data you can whenever and wherever possible."
- Expectations
  - Gathered data will have value either for the purpose collected or for a purpose not envisioned.

Cyber Security

E-Commerce

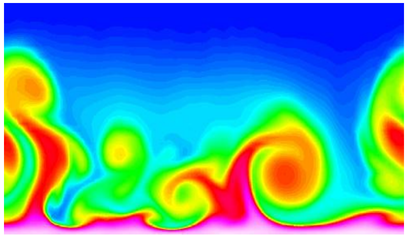


Traffic Patterns



Social Networking: Twitter

Sensor Networks



Computational Simulations

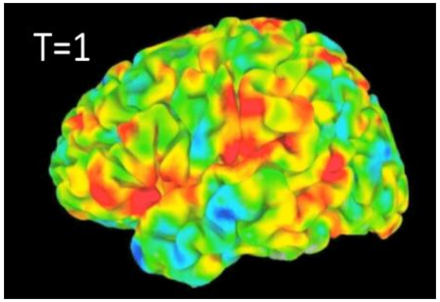
Why Data Mining? Commercial Viewpoint

- Lots of data is being collected and warehoused
  - Web data
    - Google has Peta Bytes of web data
    - Facebook has billions of active users
  - purchases at department/ grocery stores, e-commerce
    - Amazon handles millions of visits/day
  - Bank/Credit Card transactions
- Computers have become cheaper and more powerful
- Competitive Pressure is Strong
  - Provide better, customized services for an edge (e.g. in Customer Relationship Management)

Why Data Mining? Scientific Viewpoint

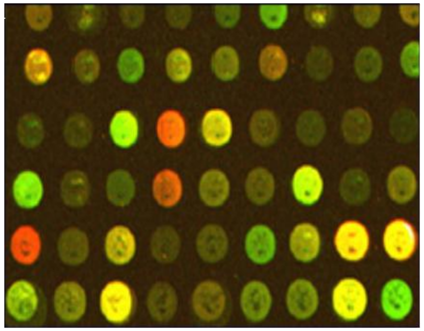
- Data collected and stored at enormous speeds
  - remote sensors on a satellite
    - NASA EOSDIS archives over petabytes of earth science data / year
  - telescopes scanning the skies
    - Sky survey data
  - High-throughput biological data
  - scientific simulations
    - terabytes of data generated in a few hours

- Data mining helps scientists
  - in automated analysis of massive datasets
  - In hypothesis formation

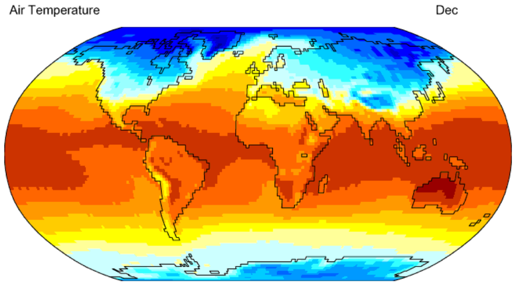


fMRI Data from Brain

Sky Survey Data

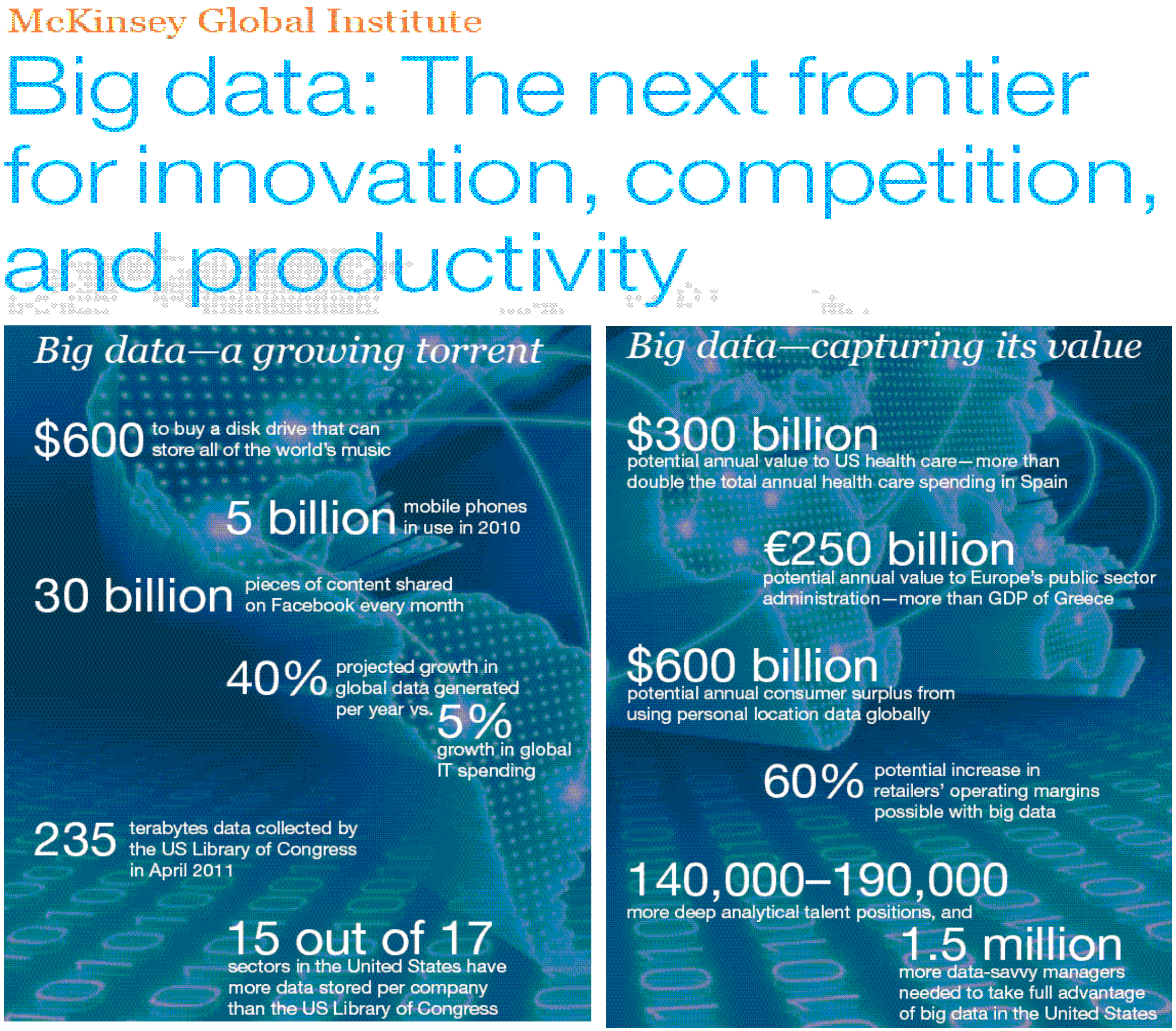


Gene Expression Data



Surface Temperature of Earth

Great opportunities to improve productivity in all walks of life



McKinsey Global Institute

Big data: The next frontier for innovation, competition, and productivity

Big data—a growing torrent

$600 to buy a disk drive that can store all of the world's music

5 billion mobile phones in use in 2010

30 billion pieces of content shared on Facebook every month

40% projected growth in global data generated per year vs. 5% growth in global IT spending

235 terabytes data collected by the US Library of Congress in April 2011

15 out of 17 sectors in the United States have more data stored per company than the US Library of Congress

Big data—capturing its value

$300 billion potential annual value to US health care—more than double the total annual health care spending in Spain

€250 billion potential annual value to Europe's public sector administration—more than GDP of Greece

$600 billion potential annual consumer surplus from using personal location data globally

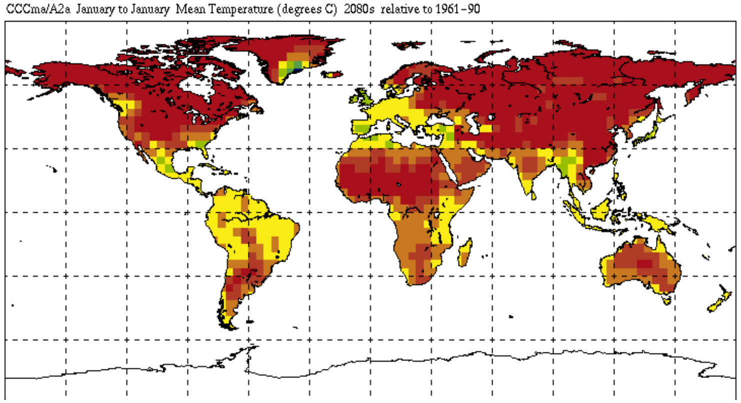
60% potential increase in retailers' operating margins possible with big data

140,000–190,000 more deep analytical talent positions, and

1.5 million more data-savvy managers needed to take full advantage of big data in the United States

Great Opportunities to Solve Society’s Major Problems

Improving health care and reducing costs


CCCma/A2a January to January Mean Temperature (degrees C) 2080s relative to 1961-90

Predicting the impact of climate change

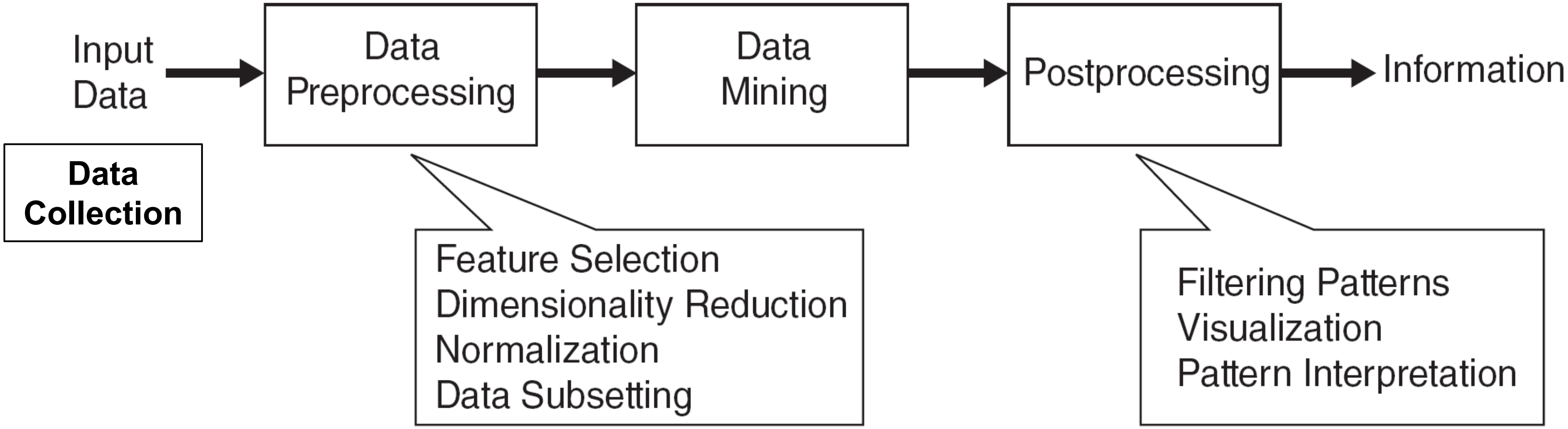
Finding alternative/ green energy sources

Reducing hunger and poverty by increasing agriculture production

What is Data Mining?

- Many Definitions
  - Non-trivial extraction of implicit, previously unknown and potentially useful information from data
  - Exploration & analysis, by automatic or semi-automatic means, of large quantities of data in order to discover meaningful patterns

The process of knowledge discovery in databases (KDD)



Input Data

Data Preprocessing

Data Mining

Postprocessing

Information

Data Collection

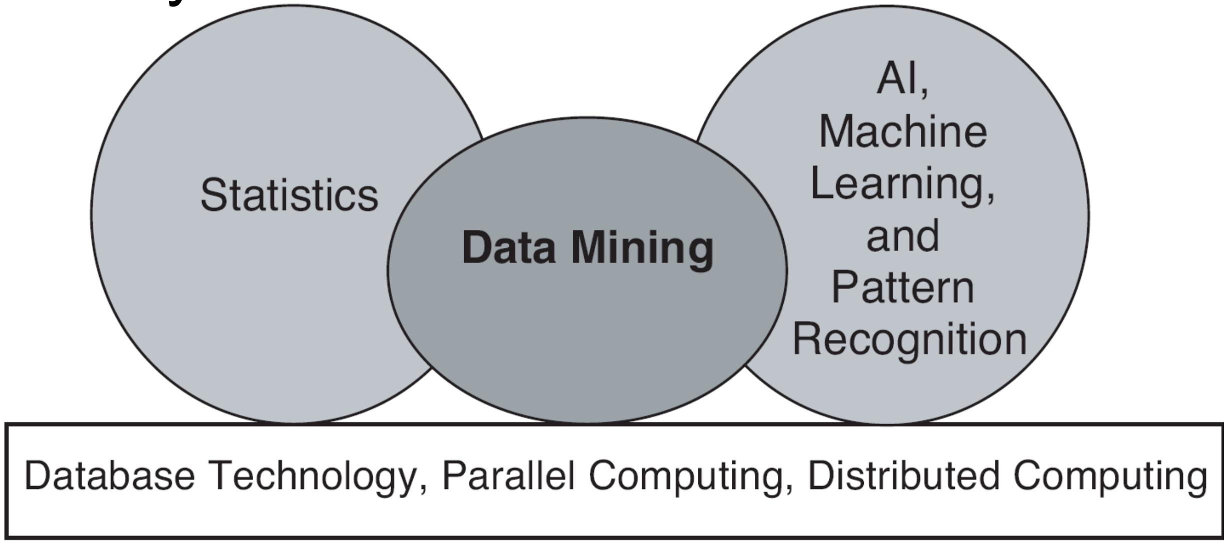
Feature Selection
Dimensionality Reduction
Normalization
Data Subsetting

Filtering Patterns
Visualization
Pattern Interpretation

Origins of Data Mining

- Draws ideas from machine learning/AI, pattern recognition, statistics, and database systems

- Traditional techniques may be unsuitable due to data that is
  - Large-scale
  - High dimensional
  - Heterogeneous
  - Complex
  - Distributed


Statistics
Data Mining
AI, Machine Learning, and Pattern Recognition
Database Technology, Parallel Computing, Distributed Computing

- A key component of the emerging field of data science and data-driven discovery

อะไรไม่ใช่ Data mining

1. ใช้คำสั่ง SQL เช่น SELECT * FROM customers WHERE city = 'Bangkok';

แค่ดึงรายชื่อลูกค้าในกรุงเทพฯ — ไม่มีการค้นหารูปแบบใหม่

2. พิมพ์ค้นหาใน Google ว่า “ร้านกาแฟใกล้ฉัน” เป็นการค้นคืนข้อมูล (search engine retrieval)

3. เปิดรายงานยอดขายรายเดือนจาก Excel หรือระบบ ERP เรียกดูข้อมูลสรุปที่มีอยู่แล้ว ไม่ได้วิเคราะห์เชิงรูปแบบ

4. ดึง log รายการโทรออกจากระบบมือถือ เรียกดูบันทึกข้อมูล ไม่ได้วิเคราะห์ความสัมพันธ์ของพฤติกรรม

5. ค้นหาชื่อนักศึกษาในฐานข้อมูลทะเบียน การ query ตรง ๆ ไม่มีการเรียนรู้หรือพยากรณ์

อะไรไม่ใช่ Data mining

6. ใช้ระบบ library search ค้นหนังสือตามชื่อเรื่องหรือชื่อผู้แต่ง
ค้นหาตรง ไม่ได้ค้นหารูปแบบเชิงสถิติ

7. เรียกดูยอดขายสินค้าประจำวันจาก dashboard
การ “reporting” ไม่ใช่ “mining”

8. คำสั่ง filter ใน Excel เพื่อดูข้อมูลเฉพาะบางแถว
การคัดกรองข้อมูล ไม่ใช่การค้นพบความรู้ใหม่

9. ค้นหาไฟล์เอกสารในคอมพิวเตอร์โดยใช้ชื่อไฟล์หรือคีย์เวิร์ด
การค้นคืนข้อมูล ไม่ใช่การวิเคราะห์เชิงลึก

10. เปิดดูประวัติการชำระเงินของลูกค้ารายหนึ่ง
ดึงข้อมูลเฉพาะเจาะจง ไม่มีการหา pattern หรือคาดการณ์

Data mining เป็นส่วนสำคัญของกระบวนการ “การค้นพบความรู้จากฐานข้อมูล” (Knowledge Discovery in Databases: KDD) ซึ่งเป็นกระบวนการใหญ่ที่เปลี่ยนข้อมูลดิบให้กลายเป็นความรู้ที่มีประโยชน์

Data Mining Tasks

- Prediction Methods

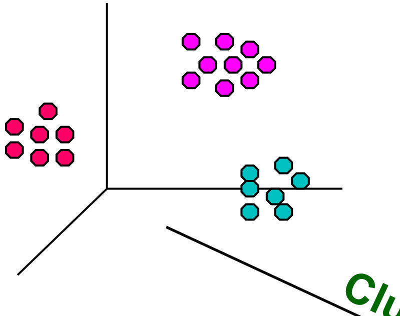
  $((x_1, x_2, x_3), y)$

  - Use some variables to predict unknown or future values of other variables.
  - Classification, Regression

- Description Methods
  - Find human-interpretable patterns that describe the data.
  - Clustering, Association, Deviation, Anomaly, Change Detection, Summarization

From [Fayyad, et.al.] Advances in Knowledge Discovery and Data Mining, 1996

Data Mining Tasks …

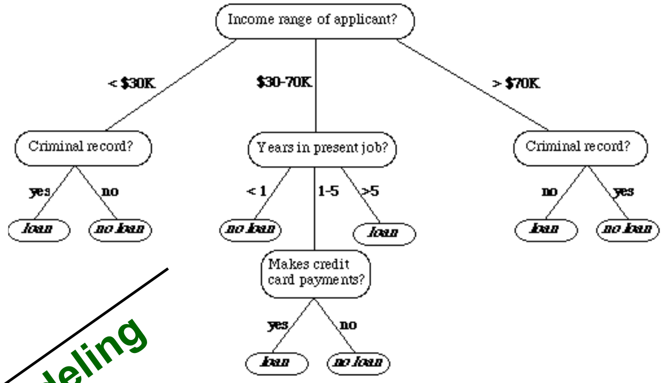


Clustering

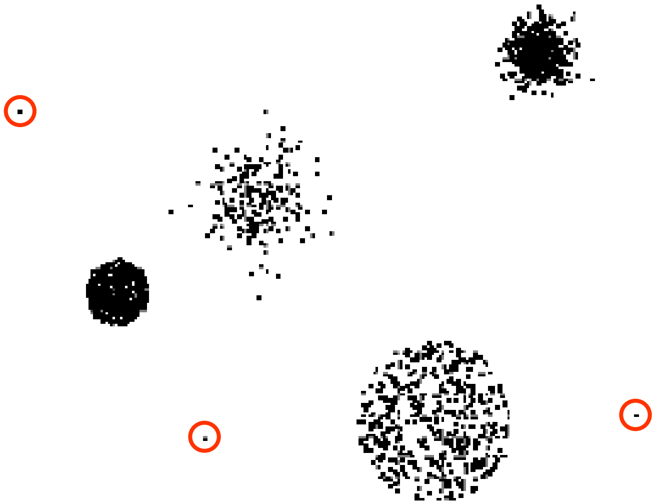
Data

Tid	Refund	Marital Status	Taxable Income	Cheat
1	Yes	Single	125K	No
2	No	Married	100K	No
3	No	Single	70K	No
4	Yes	Married	120K	No
5	No	Divorced	95K	Yes
6	No	Married	60K	No
7	Yes	Divorced	220K	No
8	No	Single	85K	Yes
9	No	Married	75K	No
10	No	Single	90K	Yes
11	No	Married	60K	No
12	Yes	Divorced	220K	No
13	No	Single	85K	Yes
14	No	Married	75K	No
15	No	Single	90K	Yes

Predictive Modeling



Anomaly Detection



Association Rules

Milk
Pampers
Baby-Dry

Data Mining Tasks…

- Prediction Methods

$((x_1, x_2, x_3), y)$

1. Classification – for discrete target variables
2. Regression – for continuous target variables

Ex ปัญหาต่อไปนี้เป็น Classification หรือ Regression

1. ผู้ใช้งานเว็บจะซื้อสินค้าหรือไม่
2. ราคาหุ้นในอนาคต

Predictive Modeling: Classification

- Find a model for class attribute as a function of the values of other attributes

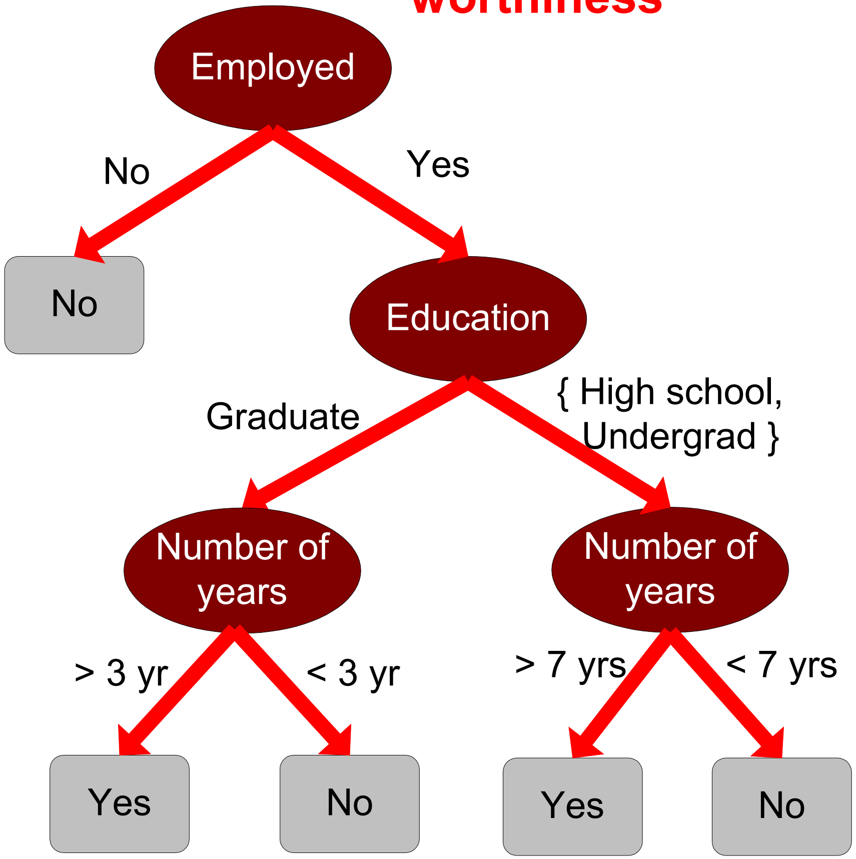
$((x_1, x_2, x_3), y)$

other attributes

Class/ label/ target

Tid	Employed	Level of Education	# years at present address	Credit Worthy
1	Yes	Graduate	5	Yes
2	Yes	High School	2	No
3	No	Undergrad	1	No
4	Yes	High School	10	Yes
…	…	…	…	…

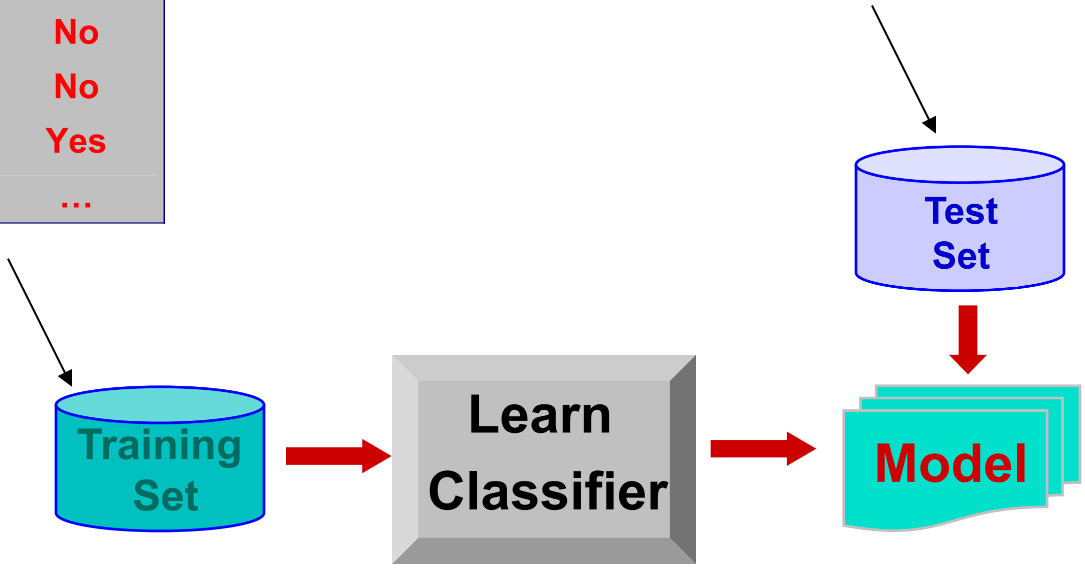
Model for predicting credit worthiness



Classification Example

	categorical	categorical	quantitative	class
Tid	**Employed**	**Level of Education**	**# years at present address**	**Credit Worthy**
1	Yes	Graduate	5	Yes
2	Yes	High School	2	No
3	No	Undergrad	1	No
4	Yes	High School	10	Yes
…	…	…	…	…

Tid	**Employed**	**Level of Education**	**# years at present address**	**Credit Worthy**
1	Yes	Undergrad	7	?
2	No	Graduate	3	?
3	Yes	High School	2	?
…	…	…	…	…



Examples of Classification Task

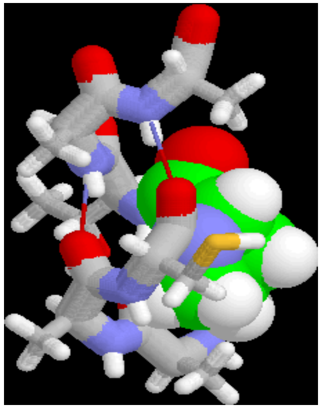
- Classifying credit card transactions as legitimate or fraudulent

- Classifying land covers (water bodies, urban areas, forests, etc.) using satellite data

- Categorizing news stories as finance, weather, entertainment, sports, etc

- Identifying intruders in the cyberspace

- Predicting tumor cells as benign or malignant



- Classifying secondary structures of protein as alpha-helix, beta-sheet, or random coil

Classification: Application 1

- Fraud Detection
  - **Goal:** Predict fraudulent cases in credit card transactions.
  - **Approach:**
    - Use credit card transactions and the information on its account-holder as attributes.
      - When does a customer buy, what does he buy, how often he pays on time, etc
    - Label past transactions as fraud or fair transactions. This forms the class attribute.
    - Learn a model for the class of the transactions.
    - Use this model to detect fraud by observing credit card transactions on an account.

Classification: Application 2

- Churn prediction for telephone customers
  - **Goal:** To predict whether a customer is likely to be lost to a competitor.
  - **Approach:**
    - Use detailed record of transactions with each of the past and present customers, to find attributes.
      - How often the customer calls, where he calls, what time-of-the day he calls most, his financial status, marital status, etc.
    - Label the customers as loyal or disloyal.
    - Find a model for loyalty.

From [Berry & Linoff] Data Mining Techniques, 1997

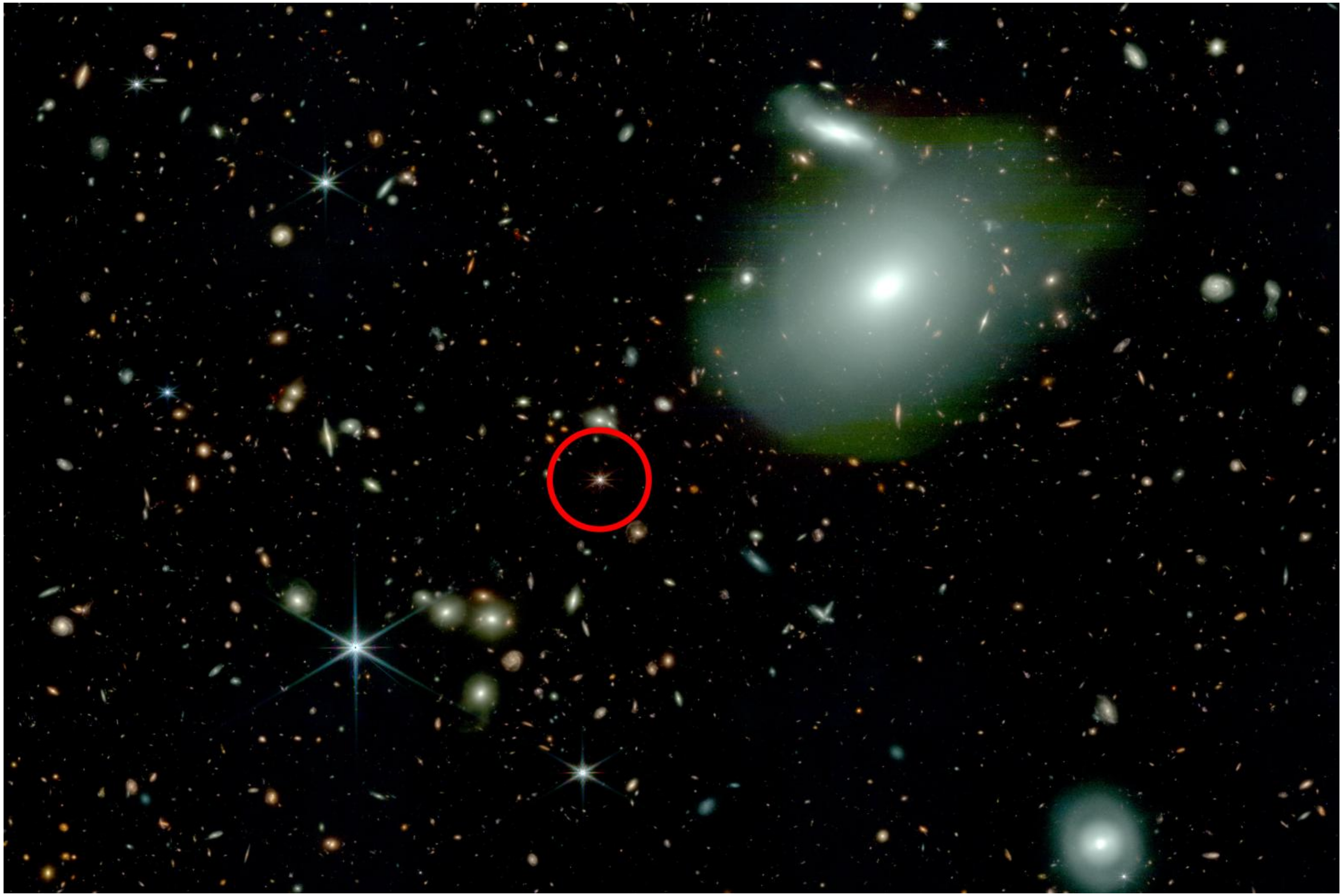
Classification: Application 3

- Sky Survey Cataloging
  - **Goal:** To predict class (star or galaxy) of sky objects, especially visually faint ones, based on the telescopic survey images (from Palomar Observatory).
    - 3000 images with 23,040 x 23,040 pixels per image.

ลดมิติ

  - **Approach:**
    - Segment the image.
    - Measure image attributes (features) - 40 of them per object.
    - Model the class based on these features.
    - Success Story: Could find 16 new high red-shift quasars, some of the farthest objects that are difficult to find!

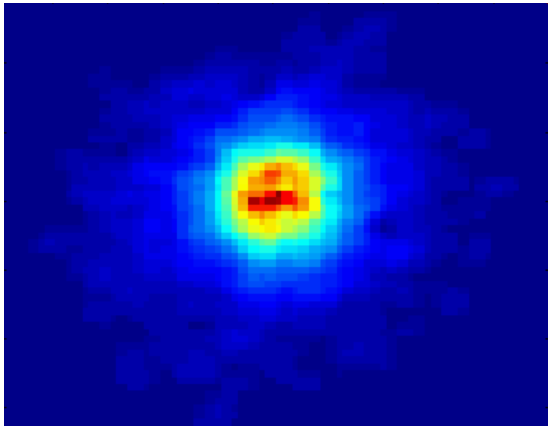
From [Fayyad, et.al.] Advances in Knowledge Discovery and Data Mining, 1996



Classifying Galaxies

Courtesy: http://aps.umn.edu

Early



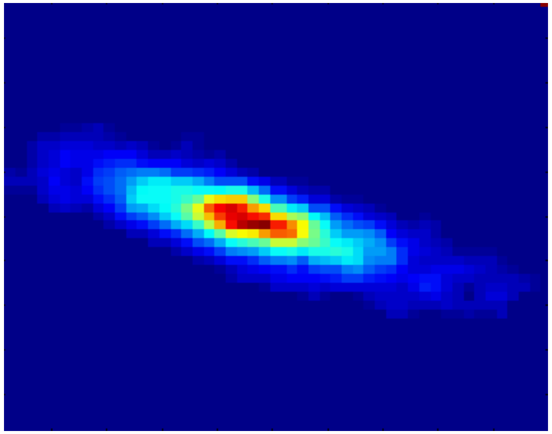
Class:

- **Stages of Formation**

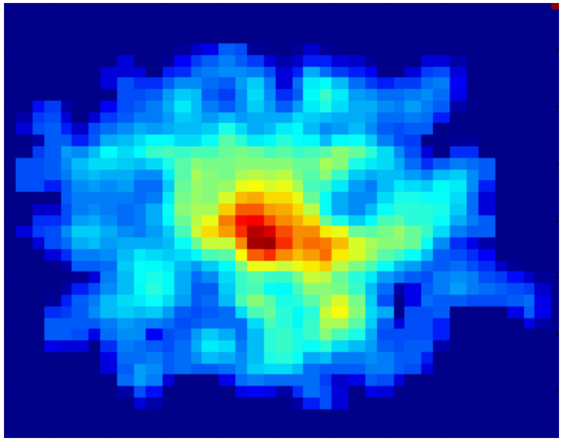
Attributes:

- **Image features,**
- **Characteristics of light waves received, etc.**

Intermediate



Late



Data Size:

- **72 million stars, 20 million galaxies**
- **Object Catalog: 9 GB**
- **Image Database: 150 GB**

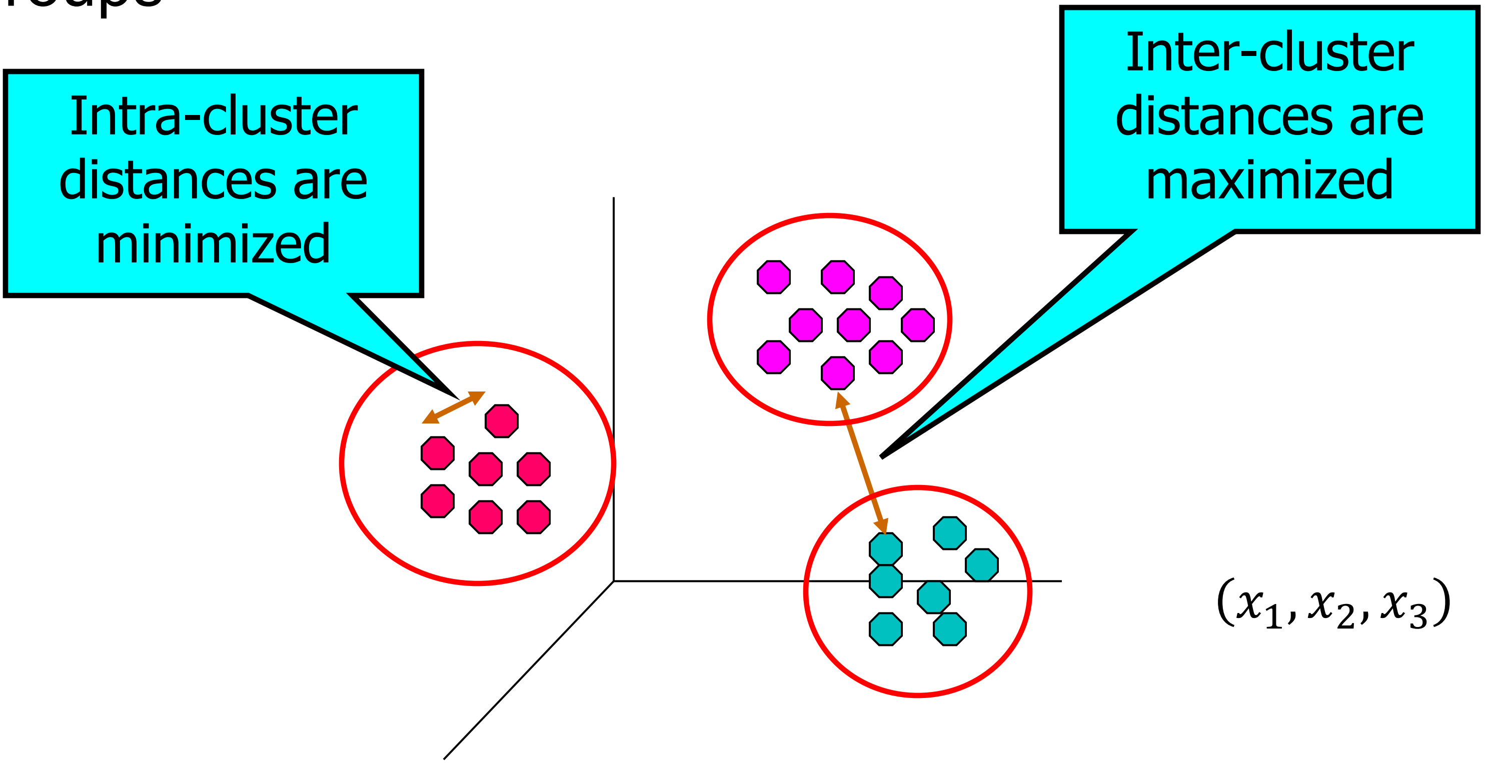
Regression

$((x_1, x_2, x_3), y)$

- Predict a value of a given continuous valued variable based on the values of other variables, assuming a linear or nonlinear model of dependency.
- Extensively studied in statistics, neural network fields.
- Examples:
  - Predicting sales amounts of new product based on advetising expenditure.
  - Predicting wind velocities as a function of temperature, humidity, air pressure, etc. $((x_1, x_2, x_3), y)$
  - Time series prediction of stock market indices.

Clustering

- Finding groups of objects such that the objects in a group will be similar (or related) to one another and different from (or unrelated to) the objects in other groups

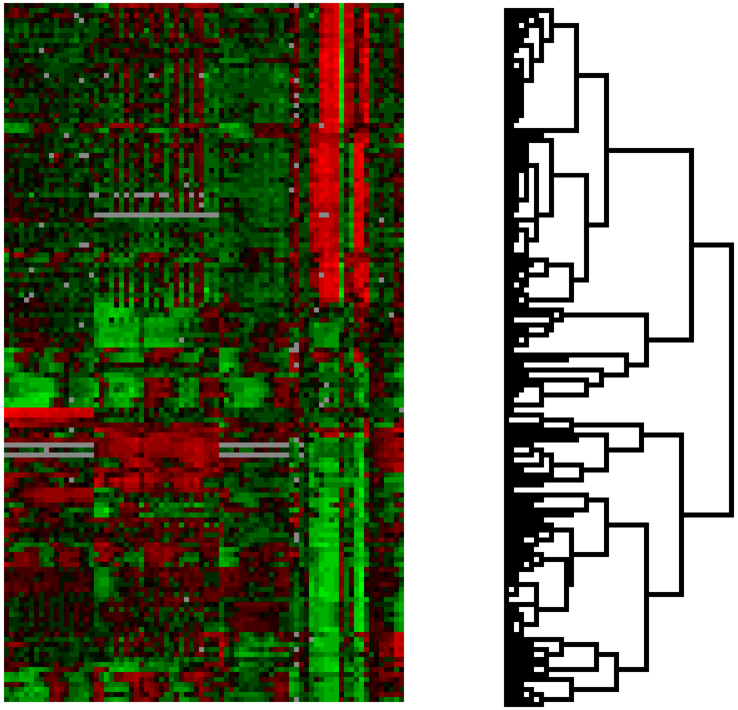


Intra-cluster distances are minimized

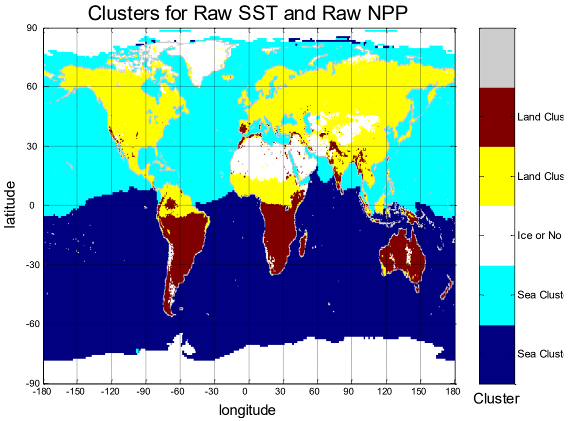
Inter-cluster distances are maximized

Applications of Cluster Analysis

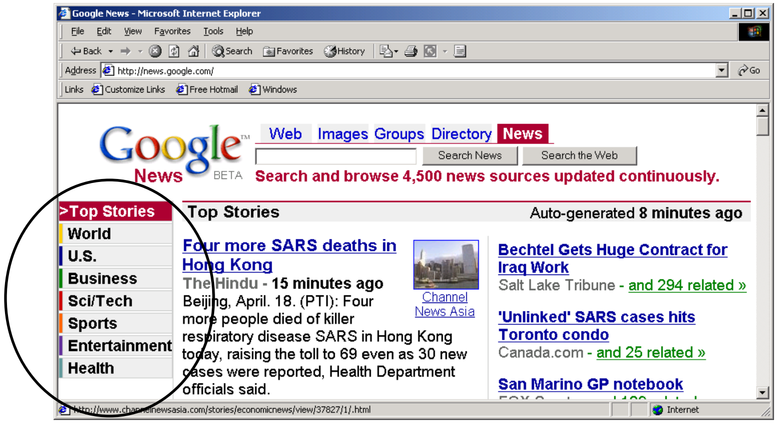
- **Understanding**
  - Custom profiling for targeted marketing
  - Group related documents for browsing
  - Group genes and proteins that have similar functionality
  - Group stocks with similar price fluctuations
- **Summarization**
  - Reduce the size of large data sets



Courtesy: Michael Eisen



Use of K-means to partition Sea Surface Temperature (SST) and Net Primary Production (NPP) into clusters that reflect the Northern and Southern Hemispheres.



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Top Stories Auto-generated 8 minutes ago

Four more SARS deaths in Hong Kong
The Hindu - 15 minutes ago
Beijing, April. 18. (PTI): Four more people died of killer respiratory disease SARS in Hong Kong today, raising the toll to 69 even as 30 new cases were reported, Health Department officials said.

Channel News Asia

Bechtel Gets Huge Contract for Iraq Work
Salt Lake Tribune - and 294 related »

'Unlinked' SARS cases hits Toronto condo
Canada.com - and 25 related »

San Marino GP notebook

http://www.channelnewsasia.com/stories/economicnews/view/37827/1/.html

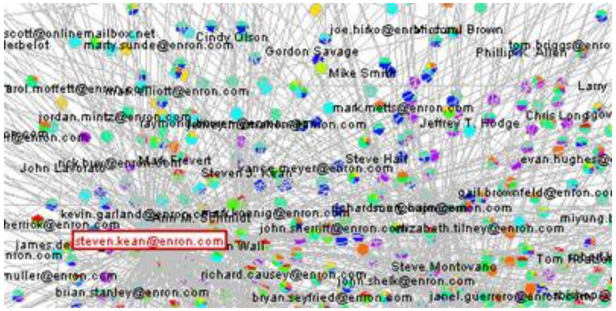
Clustering: Application 1

- Market Segmentation:
  - **Goal:** subdivide a market into distinct subsets of customers where any subset may conceivably be selected as a market target to be reached with a distinct marketing mix.
  - **Approach:**
    - Collect different attributes of customers based on their geographical and lifestyle related information.
    - Find clusters of similar customers.
    - Measure the clustering quality by observing buying patterns of customers in same cluster vs. those from different clusters.

Clustering: Application 2

- Document Clustering:
  - **Goal:** To find groups of documents that are similar to each other based on the important terms appearing in them.
  - **Approach:** To identify frequently occurring terms in each document. Form a similarity measure based on the frequencies of different terms. Use it to cluster.

Enron email dataset



Association Rule Discovery: Definition

- Given a set of records each of which contain some number of items from a given collection
  - Produce dependency rules which will predict occurrence of an item based on occurrences of other items.

TID	*Items*
1	**Bread, Coke, Milk**
2	**Beer, Bread**
3	**Beer, Coke, Diaper, Milk**
4	**Beer, Bread, Diaper, Milk**
5	**Coke, Diaper, Milk**

Rules Discovered:

{Milk} --> {Coke}
{Diaper, Milk} --> {Beer}

Association Analysis: Applications

- Market-basket analysis
  - Rules are used for sales promotion, shelf management, and inventory management

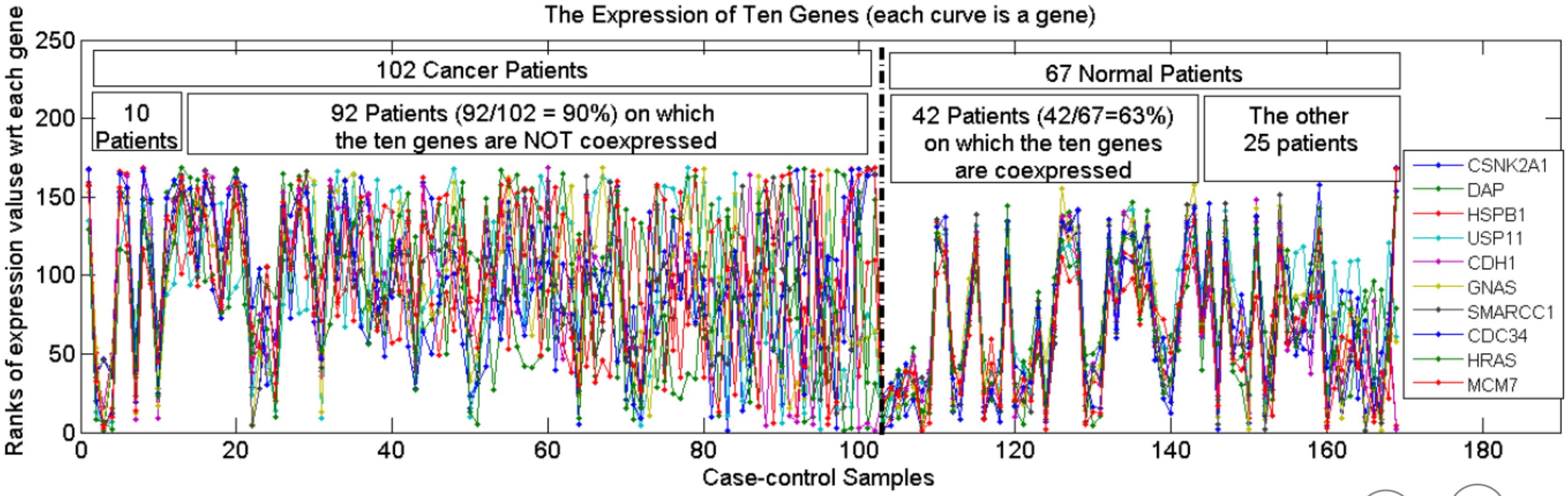
- Telecommunication alarm diagnosis
  - Rules are used to find combination of alarms that occur together frequently in the same time period

- Medical Informatics
  - Rules are used to find combination of patient symptoms and test results associated with certain diseases

Association Analysis: Applications

- An Example Subspace Differential Coexpression Pattern from lung cancer dataset

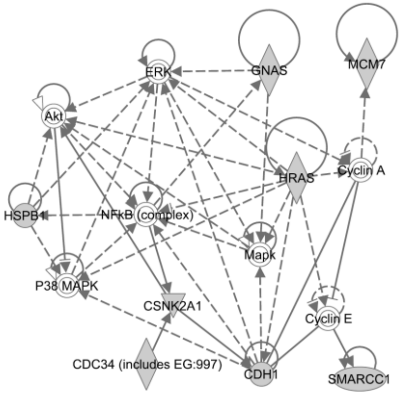
Three lung cancer datasets [Bhattacharjee et a 2001], [Stearman et al. 2005], [Su et al. 2007]



Enriched with the TNF/NFB signaling pathway which is well-known to be related to lung cancer

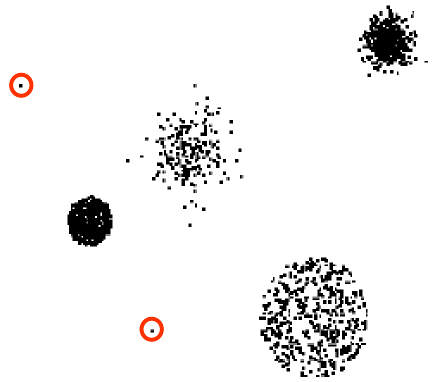
P-value: $1.4*10^{-5}$ (6/10 overlap with the pathway)

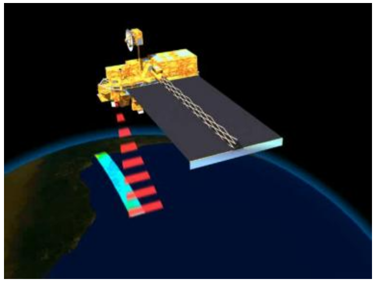
[Fang et al PSB 2010]

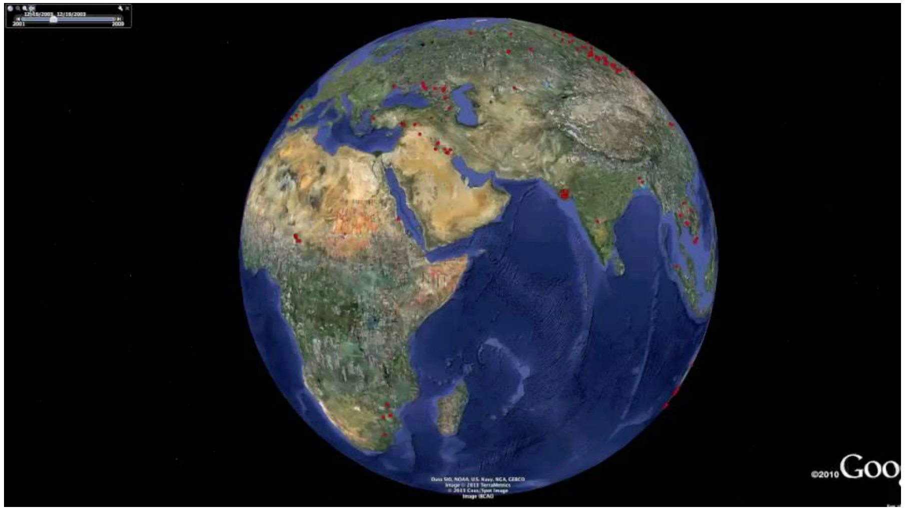


Deviation/Anomaly/Change Detection

- Detect significant deviations from normal behavior
- Applications:
  - Credit Card Fraud Detection
  - Network Intrusion Detection
  - Identify anomalous behavior from sensor networks for monitoring and surveillance.
  - Detecting changes in the global forest cover.







Motivating Challenges

- Scalability
- High Dimensionality
- Heterogeneous and Complex Data
- Data Ownership and Distribution
- Non-traditional Analysis

Summary

- ข้อมูลมีทุกที่ big data
- จำเป็นต้องใช้ Data Mining เพราะปริมาณ ความซับซ้อน และความเร็ว
- Data Mining = non-trivial + unknown + useful
- ไม่ใช่ query หรือ Google
- มีงาน 6 แบบที่ data mining จัดการ
- มีความท้าทาย 5 ประเภทหลัก

การบ้าน

1. สรุป กระบวนการ KDD ประกอบด้วยอะไร แต่ละขั้นคืออะไร

2. อธิบายขั้นตอนของ กระบวนการ KDD หรับปัญหา **วิเคราะห์การเลิกเป็นสมาชิกของค่ามือถือ ปัญหาลูกค้าคนนี้จะยกเลิกบริการไหม**