Data Mining: Introduction

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About The Instructor

- Education
  - Bachelor and master in mathematics, SYSU
  - PhD in computer science, HKBU
- Research Experience
  - Postdoc at Rutgers
  - Postdoc at Johns Hopkins
  - Postdoc at HKBU
- Research interests
  - Machine learning: feature fusion, transfer learning, etc.
  - Computer vision: intelligent video surveillance, etc.
  - Medical data analysis: diagnosis and prediction models, etc.

About This Course

- Instructor's contact
  - Office: 超算中心5楼529C
  - Email: majh8@mail.sysu.edu.cn
- Teaching assistant
  - 王子佳, 2582822457@qq.com
  - 谢国添, 1224617026@qq.com
- Lecture hours and venue
  - Monday 1-2节 (1-9 weeks), D303
  - Wednesday 9-10节, A306
- Prerequisite
  - Linear Algebra, Statistics, Data Structure, Programing

About This Course

- Course Contents
  - Supervised learning
    - Linear regression, logistic regression, SVM, decision tree, ensemble methods, neural networks, overfitting
  - Unsupervised learning
    - PCA, manifold learning, clustering
  - Recommendation system
    - Collaborative Filtering, UV-Decomposition
  - Association analysis
    - Apriori Algorithm, frequent itemset
  - Recent advanced techniques
    - PageRank, hashing, Stochastic gradient descent, CNN

About This Course

- Recommended readings
  - 周志华. 机器学习. 清华大学出版社, 2016.
  - Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman. Mining of Massive Datasets, Second Edition. Cambridge University Press, 2014.
  - Pang-Ning Tan, Michael Steinbach, Vipin Kumar. Introduction to data mining. Pearson, 2006.
  - T. Hastie, R. Tibshirani, and J. Friedman. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Ed. Springer, 2009.
- Assessment
  - 3~4 Assignments, mid-term project, final open-ended project, attendance, answer question

Why Data Mining?

- Large-scale Data is Everywhere!

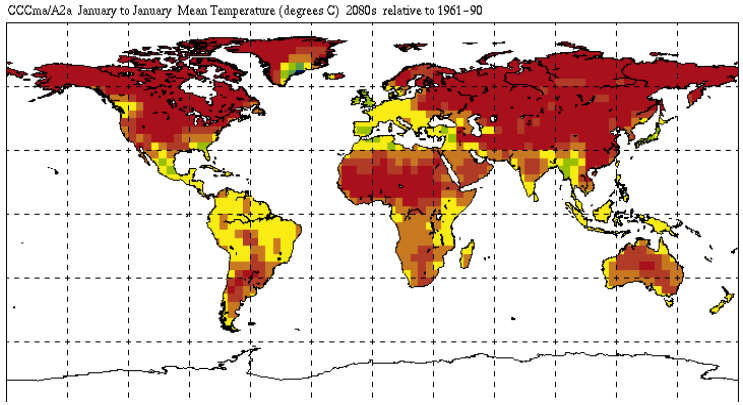
YouTube 300 hours
video uploaded to YouTube every minute

500 million
tweets on Twitter per day

30 billion
pieces of content shared on Facebook every month

- Great Opportunities to Solve Society's Major Problems

Improving health care and reducing costs



Predicting the impact of climate change

Why Data Mining?

- Commercial Viewpoint

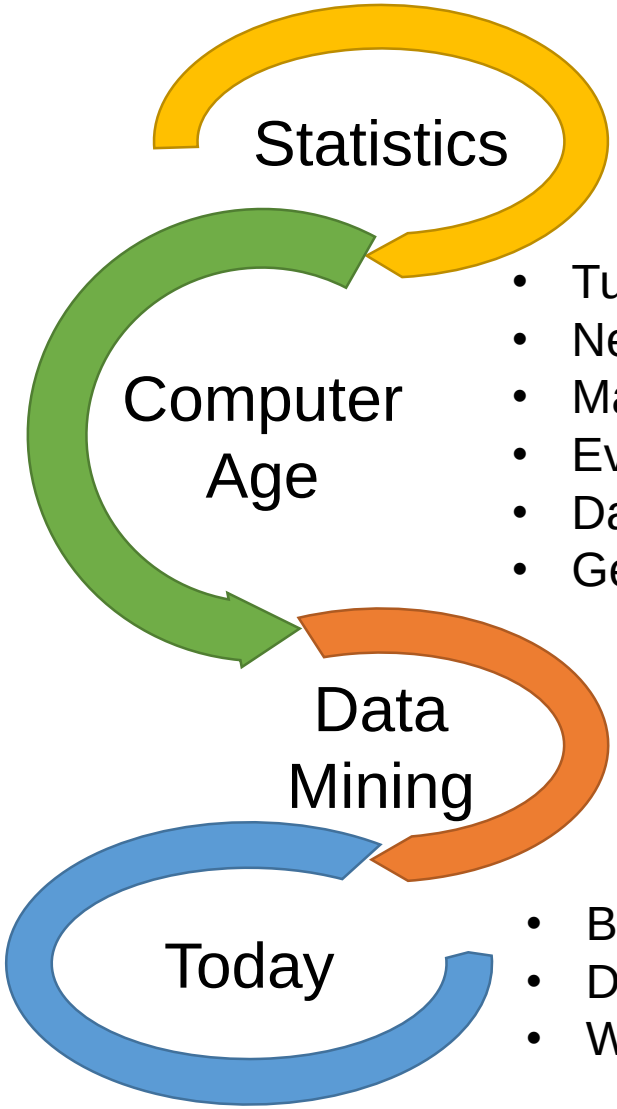
  - Provide better, customized services for an edge, e.g.
    - Finance, Medicine, Manufacturing, Customer Relationship Management, Fraud Detection, etc.
  - Conclusion: help to find a **GOOD JOB**

Why Data Mining?

- Research Viewpoint
  - Related refereed journals, e.g.,
    - IEEE Trans. on Knowledge and Data Engineering (TKDE)
    - IEEE Trans. on Pattern Analysis and Machine Intelligence (TPAMI)
    - Journal of Machine Learning Research
    - International Journal of Computer Vision
  - Related refereed conferences, e.g.,
    - ACM Knowledge Discovery and Data Mining (KDD)
    - International Joint Conference on Artificial Intelligence (IJCAI)
    - International Conference on Machine Learning (ICML)
    - International Conference on Computer Vision (ICCV)
  - Conclusion: help to pursue **ADVANCED DEGREE**

What is Data Mining?

History of Data Mining



- Bayes' theorem (1763)
- Regression (1805)

- Turning machine (1936)
- Neural networks (1943)
- Machine learning (1959)
- Evolutionary Computation (1965)
- Databases (1970s)
- Genetic algorithms (1975)

- KDD (1989)
- SVM (1992)
- Data science teams (2001)
- Moneyball (2003)

- Big data
- Deep learning
- Widespread adoption

What is Data Mining?

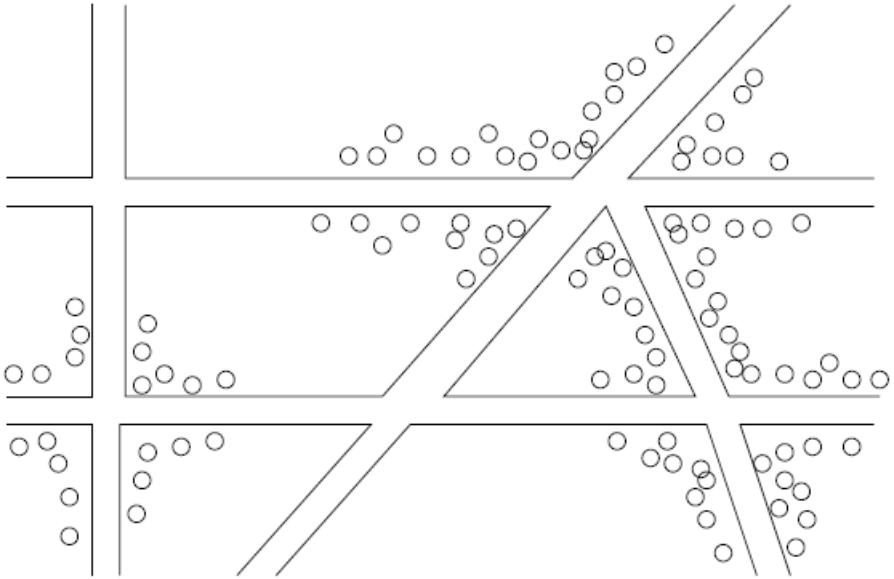
- Definition
  - Extract useful patterns from (usually large-scale) data

- But to extract the knowledge data needs to be
  - Stored (systems)
  - Managed (databases)
  - And ANALYZED ← this class

Data Mining ≈ Big Data ≈
Predictive Analytics ≈ Data Science

What is Data Mining?

- Discovery of cholera (霍乱)
  - Instance of clustering to solve the cholera problem in London



Plotting cholera cases on a map of London

  - Knowledge: high chance of cholera in clusters around intersections with contaminated wells that had become

What is (not) Data Mining?

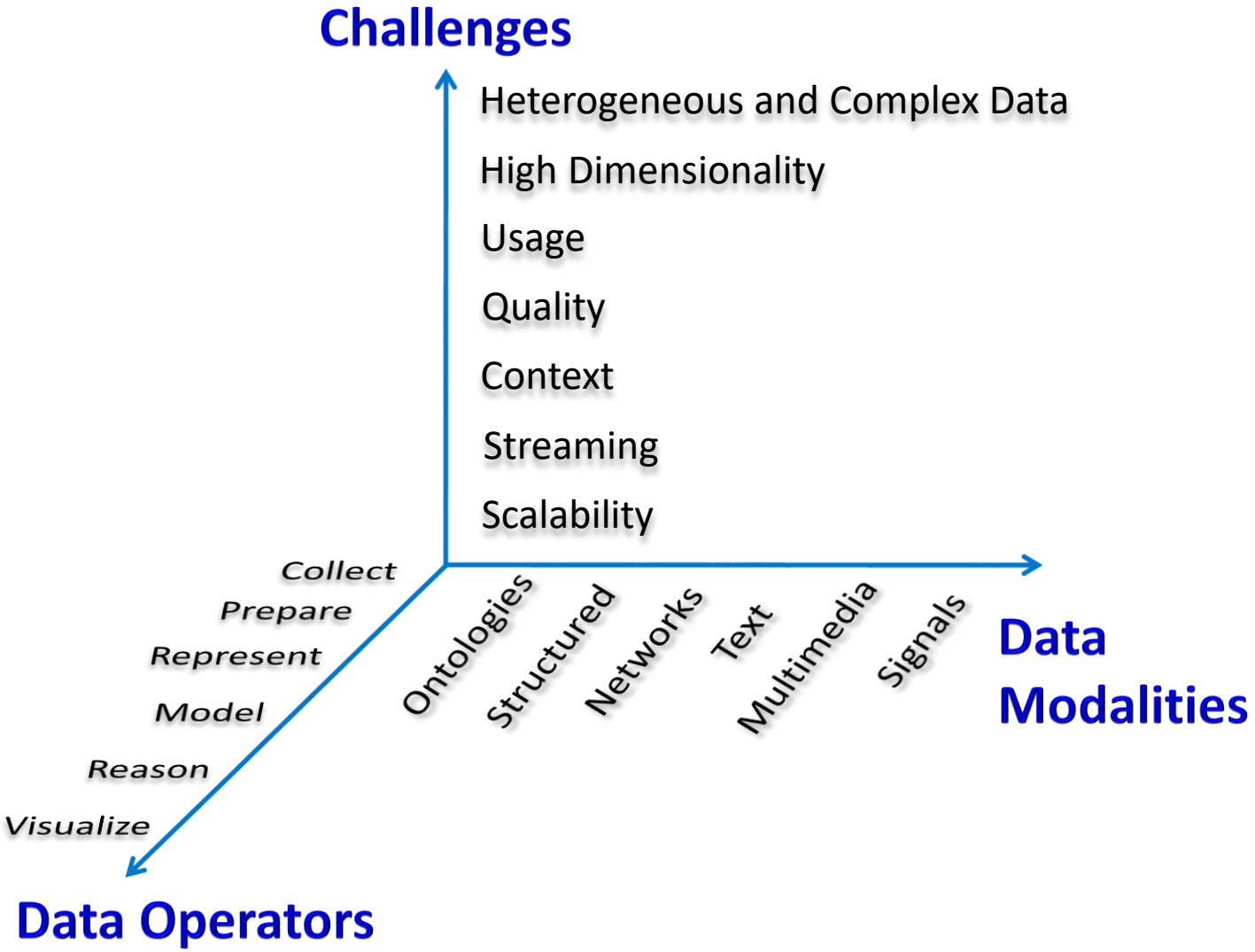
- What is not Data Mining?
  - Look up phone number in phone directory
  - Query a Web search engine for information about "Amazon"

- What is Data Mining?
  - Certain names are more prevalent in certain US locations (O'Brien, O'Rourke, O'Reilly… in Boston area)
  - Group together similar documents returned by search engine according to their context (e.g., Amazon rainforest, Amazon.com)

Data Mining Tasks

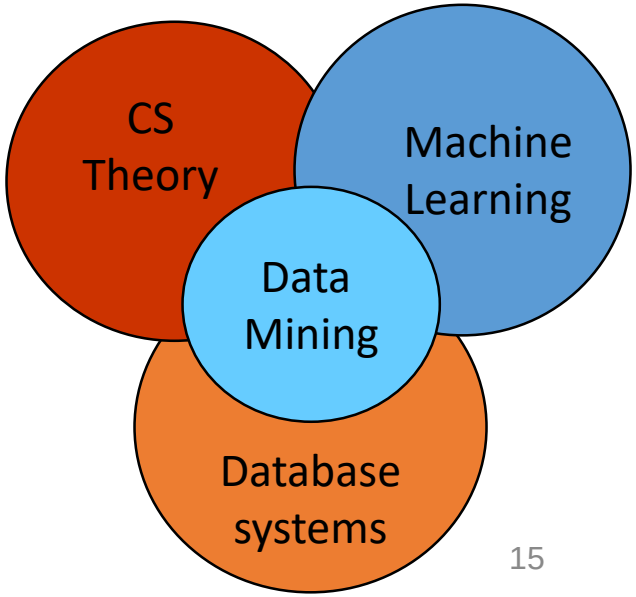
- **Predictive methods**
  - Use some variables to predict unknown or future values of other variables, e.g.,
    - Regression: time series prediction of stock market indices
    - Classification: classify credit card transactions as legal or not
    - Recommender systems: predict the someone's rating or preference for a movie
- **Descriptive methods**
  - Find human-interpretable patterns that describe data
    - Clustering: find groups of documents that are similar to each other based on the important terms
    - Association Analysis: market-basket analysis for rule-based sales promotion

What Matters for Data Mining?



Data Mining: Cultures

- **Data mining overlaps with:**
  - **Databases:** Large-scale data, simple queries
  - **Machine learning:** Small data, Complex models
  - **CS Theory:** (Randomized) Algorithms
- **Different cultures:**
  - To a DB person, data mining is an extreme form of **analytic processing** – queries that examine large amounts of data
    - Result is the query answer
  - To a ML person, data-mining is the **inference of models**
    - Result is the parameters of the model
- **In this class we will do both!**



Quiz

- Discuss whether or not each of the following activities is a data mining task
  - Predicting the outcomes of tossing a (fair) pair of dice
    - No. Since the die is fair, this is a probability calculation.
  - Monitoring the heart rate of a patient for abnormalities
    - Yes, known as anomaly detection or classification problem.
  - Extracting the frequencies of a sound wave
    - No. This is signal processing.
  - Dividing customers according to their gender
    - No. This is a simple database query.
  - Predicting the future stock price of a company using historical records
    - Yes, known as predictive modelling, solved by e.g. regression

How do you want that data?

References

- J. Leskovec, A. Rajaraman, J. Ullman: Mining of Massive Datasets, http://www.mmds.org
- P.-N. Tan, M. Steinbach, V. Kumar: Introduction to data mining, Second Edition, https://www-users.cs.umn.edu/~kumar001/dmbook/index.php