
CSE 40647/60647
Data Science

Chapter 1. Introduction

Meng Jiang

Data Science

The Instructor

- Dr. Meng Jiang (www.meng-jiang.com)

B.S. and Ph.D.

Visiting Ph.D.

Postdoc Researcher

Assistant Professor

Visiting Researcher

Visiting Researcher

Why do you take the course?

1. _____
2. _____
3. _____
4. _____
5. _____

General Learning Goals

- Learn *basic* data science concepts
- Learn *basic* methods for mining datasets
- Prerequisites:
  - Programming with **Python**
  - Data structures and Algorithms
- As a prerequisite for:
  - CSE 40625/60625: Machine Learning

Expect and Not Expect

- Expect to have:
  - The *first tiny* step of being a "data scientist"
- Don't expect to have:
  - *State-of-the-art* machine learning/AI models
    1. _____
    2. _____
  - *All* skills that your start-up idea requires
    1. _____
    2. _____
    3. _____

What is Data Science?

- "…the process of automatically discovering *useful information* in *large* repositories of data." — *Introduction to Data Mining* (Tan, Steinbach, & Kumar)
- "…the process of discovering *patterns* in data." — *Data Mining: Practical Machine Learning Tools and Techniques, 3rd Edition* (Witten, Frank, & Hall)
- "…the process of discovering *interesting patterns and knowledge* from *large* amounts of data." — *Data Mining: Concepts and Techniques, 3rd Edition* (Han, Kambler, & Pei)

Our Definition of the Course

- "…the art and craft of extracting *knowledge* from *large* bodies of *structured and unstructured* data using methods from many disciplines, including (but not limited to) machine learning, databases, probability and statistics, information theory, and data visualization."

What is/isn't Data Science?

[ ] Looking up a record in a database.

[ ] Noting that some last names occur in certain geographical areas.

[ ] Searching for a term on Google.

[ ] Taking all query results from Google and discovering that they can be grouped or categorized.

[ ] Testing a two-sample hypothesis in a clinical trial.

[ ] When doing multiple tests across many different genes, identifying very strongly significant genes.

What is/isn't Data Science?

[×] Looking up a record in a database.

No pattern is revealed by this lookup.

[√] Noting that some last names occur in certain geographical areas.

[×] Searching for a term on Google.

This is simply a "match" or "non-match".

[√] Taking all query results from Google and discovering that they can be grouped or categorized.

[×] Testing a two-sample hypothesis in a clinical trial.

The dataset is often not large.

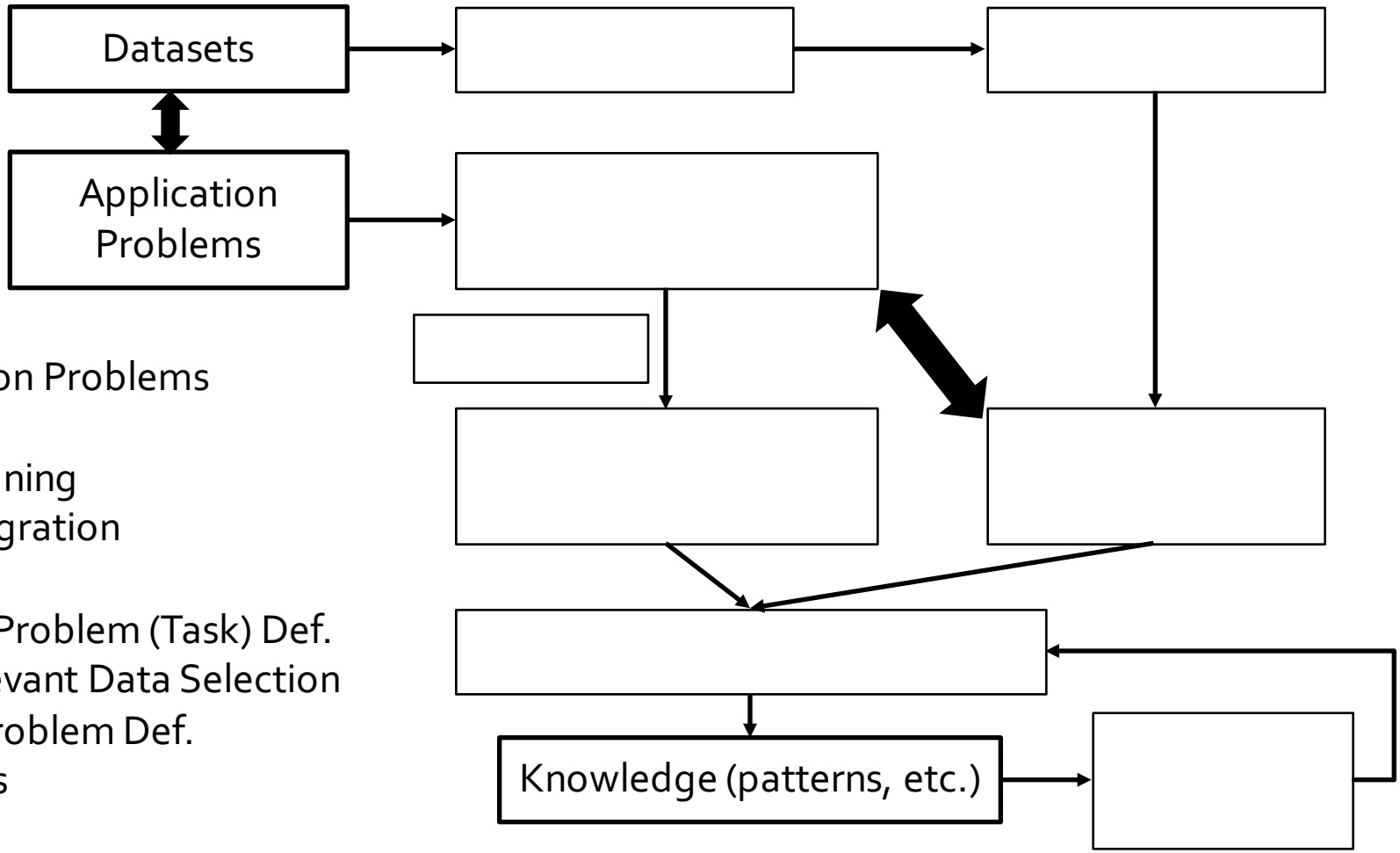
[√] When doing multiple tests across many different genes, identifying very strongly significant genes.

Is This Data Science?

[ ] Find the most popular hobby among us.

If I ask you to do the "research", what's the first step?

Data Science Research



1. Datasets
2. Application Problems

3. Data Cleaning
4. Data Integration

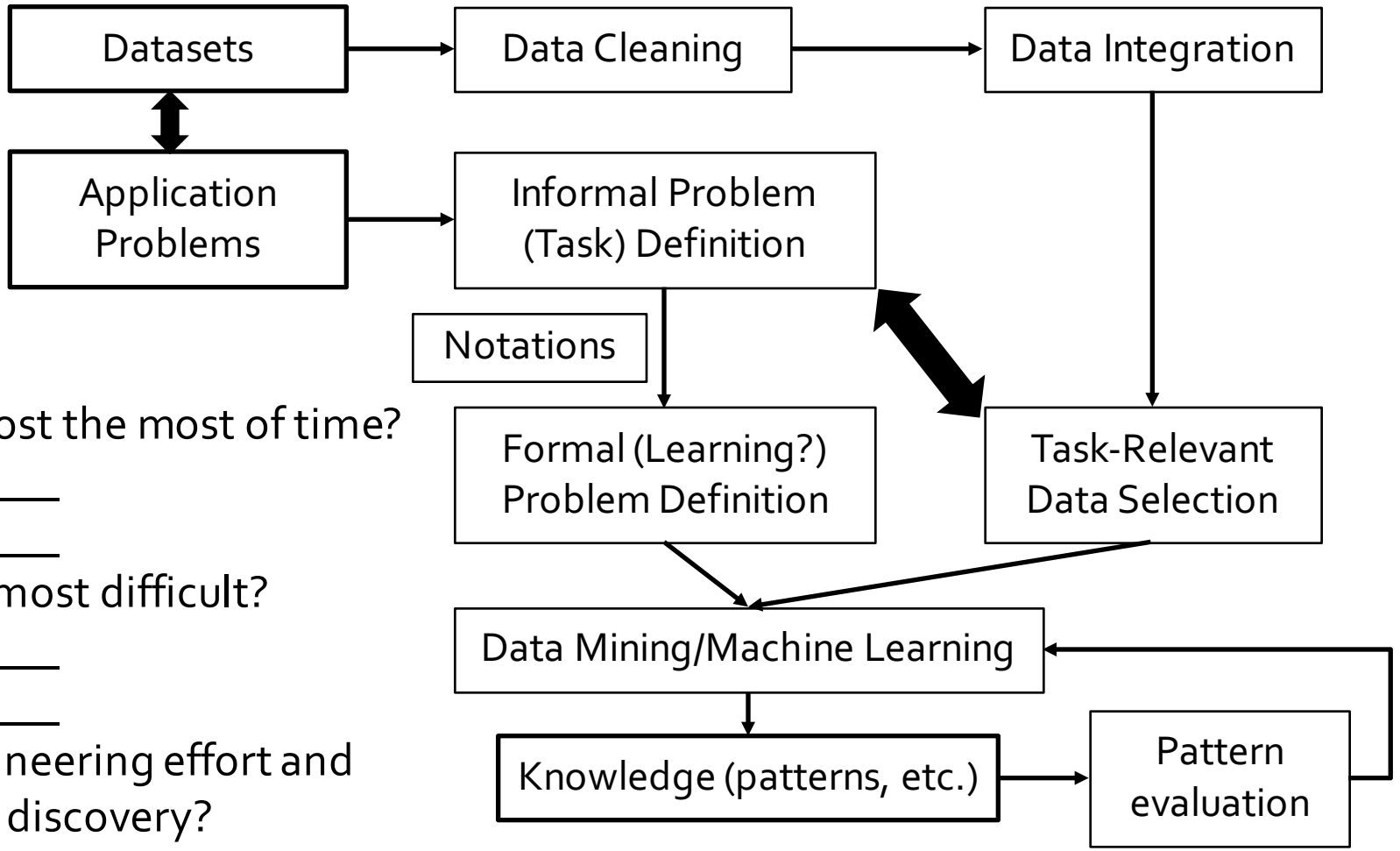
5. Informal Problem (Task) Def.
6. Task-Relevant Data Selection
7. Formal Problem Def.
8. Notations

9. Data Mining
10. Knowledge (patterns, descriptions, relations, etc.)
11. Pattern evaluation

Example

1. **Datasets:** Walmart transaction data
2. **Application Problems:** Optimize products placement for more sales
3. **Data Cleaning:** Incomplete data, noisy data, etc.
4. **Data Integration:** Multiple operational databases (markets)
5. **Informal Problem (Task) Def.:** Given transactions, which two items are often purchased together?
6. **Task-Relevant Data Selection:** Input and validation data for a task
7. **Formal Problem Def.:** Given $T = \{T_1, \ldots\}$ and $T_i \subseteq X$, find *associations* $X_j \rightarrow X_k$ that have high *support* and *confidence*.
8. **Notations:** Transaction set *T*, itemset/transaction T_i, the set of all the items X, items X_j
9. **Data Mining:** Propose an approach for association mining
10. **Knowledge (patterns, etc.):** The associations
11. **Pattern evaluation:** Sales increase?

Data Science Research



What may cost the most of time?

1. _____
2. _____

What is the most difficult?

1. _____
2. _____

What is engineering effort and what makes discovery?

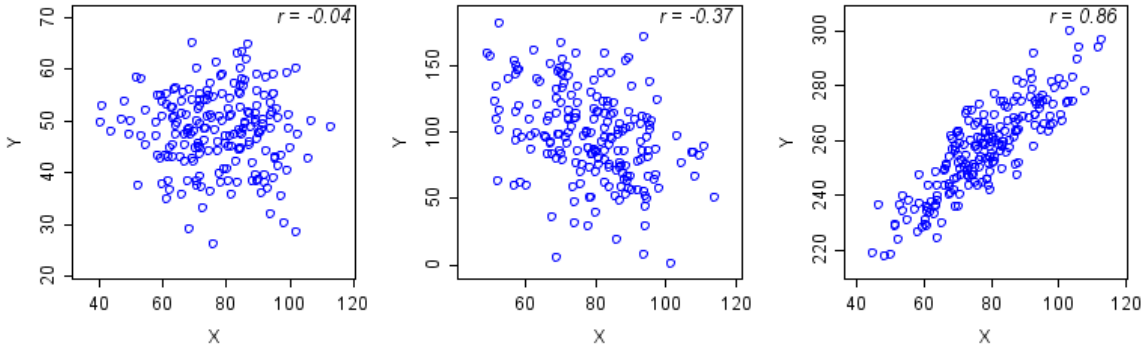
1. _____
2. _____

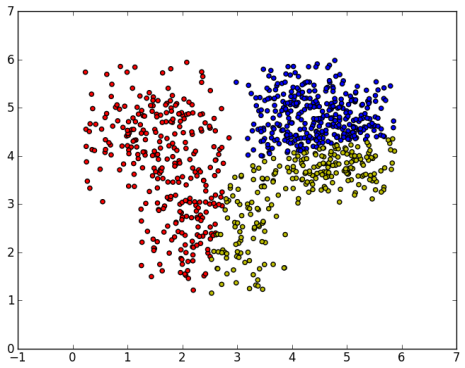
Machine Learning

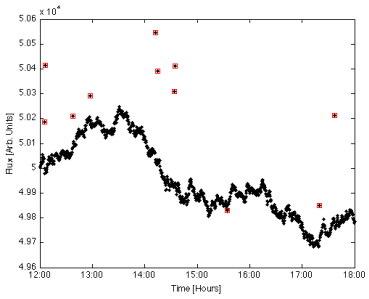
- "A computer program is said to *learn* from experience, E, with respect to some class of tasks, T, and performance measure, P, if its performance at tasks in T, as measured by P, improves with experience, E." —Tom Mitchell, *Machine Learning*
- "*Machine learning* algorithms have proven to be of great practical value in a variety of application domains. They are especially useful in *data mining problems*…" —Tom Mitchell, *Machine Learning*

Data Science Functionalities

- Generalization
- Visualization
- Frequent pattern mining and association mining
- Classification
- Clustering
- Outlier analysis







Concrete Learning Goals

- **Can process raw data: data cleaning, data integration, data reduction, dimension reduction**
- Can describe data warehouse, OLAP, data cube concepts and technology that work on multi-dimensional datasets
- **Can use Apriori and FP-Growth for frequent pattern mining**
- Can describe diverse patterns, sequential patterns, graph patterns
- **Can use Decision Tree, Naïve Bayes, Ensembles for classification**
- Can describe SVMs and Neural Networks for classification
- **Can use K-Partitioning Methods (K-Means, etc.) for clustering**
- Can describe Kernel-based Clustering and Density-based Clustering
- **Can use appropriate measures to evaluate results of different functionalities**

Syllabus and Schedule

08-22T	**Introduction**	10-12R	Classification: Naïve Bayes
08-24R	Data description	10-24T	Classification: Evaluation
08-29T	Data visualization	10-26R	Classification: Ensembles
08-31R	**Project introduction**	10-31T	Classification: SVMs
09-05T	Data cleaning and data integration	11-02R	Classification: Neural networks
09-07R	Data reduction and dimension reduction	11-07T	Clustering: Concepts
09-12T	Data cube: Concepts and operations	11-09R	Clustering: Partitioning methods
09-14R	Data cube: Data warehouse and OLAP	11-14T	Clustering: Kernel-based
09-19T	Frequent pattern mining: Apriori	11-16R	Clustering: Density-based
09-21R	Frequent pattern mining: FP-Growth	11-21T	Clustering: Evaluation
09-26T	Frequent pattern mining: Evaluation	11-28T	**Course review 2**
09-28R	Frequent pattern mining: Beyond itemset	11-30R	**Course review 3**
10-03T	**Course review 1**	12-05T	**Project presentation 1**
10-05R	**Mid-term**	12-07R	**Project presentation 2**
10-10T	Classification: Decision tree induction	12-12T	**Final**

Five Written Assignments and One Project

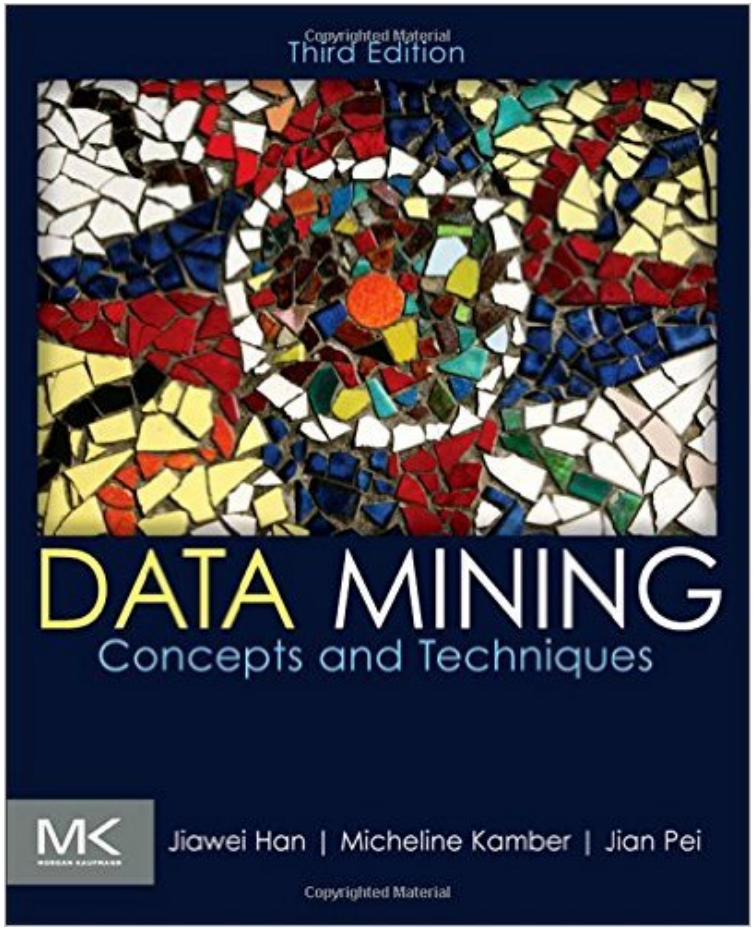
08-22T	**Introduction**	10-12R	**HW4 out**
08-24R	Data processing	10-24T	
08-29T	**HW1 out**	10-26R	
08-31R	**Project introduction Project out**	10-31T	
09-05T		11-02R	
09-07R		11-07T	Clustering
09-12T	Data cube **HW1 due, HW2 out**	11-09R	**HW4 due, HW5 out**
09-14R		11-14T	
09-19T	Frequent pattern mining	11-16R	
09-21R	**HW2 due, HW3 out**	11-21T	
09-26T		11-28T	**Course review 2 HW5 due**
09-28R		11-30R	**Course review 3 Project due**
10-03T	**Course review 1 HW3 due**	12-05T	**Project presentation 1**
10-05R	**Mid-term**	12-07R	**Project presentation 2**
10-10T	Classification	12-12T	**Final**

Grading

- **Uniform grading policy for undergraduates**
- **Individual HWs: 25%** = 5% * 5
- **Individual project: 25%** (Graduates are graded separately)
  - "Data science research bot"
  - Fed with *thousands* of data science publications
  - QA with *discovered knowledge*: Help data scientists on their research
  - Techs
    - Data cube: Paper/expert recommendation
    - Frequent pattern mining and classification: Entity recognition
    - Classification: Entity typing ($Problem, $Method, $Dataset, $Metric, $Digit…)
    - Clustering: Entity clustering
    - Evaluations
    - *Inference and prediction
  - Monitored in HWs (cube stat., ten most freq. patterns, etc.); volunteer to present and be graded by classmates and instructor; others graded by the instructor
- **Mid-term: 20%**
- **Final: 30%**
- **No quiz.**

Textbook

- Jiawei Han, Micheline Kamber and Jian Pei, Data Mining: Concepts and Techniques (3rd ed.), Morgan Kaufmann, 2011
- Our lecture does *not cover all* the content of the book.
- We provide lecture notes from the 2nd ed. of the text book.



Time and Location

- Lecture: 2:00 pm – 3:15 pm (Tuesday and Thursday), DeBartolo Hall 140
- Office hour: 3:30 pm – 4:30 pm (**Thursday**), Cushing Hall 326C
- Teaching Assistant: Qi Li (qli8)
- TA hour: 3:30 pm – 4:30 pm (**Tuesday**), Fitzpatrick Hall 247
- Website (slides): http://www.meng-jiang.com/teaching-csex0647.html
- Forum: (Piazza) https://piazza.com/class/j6dmfs52c6d5ov

References

- 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