CS60021: Scalable Data Mining

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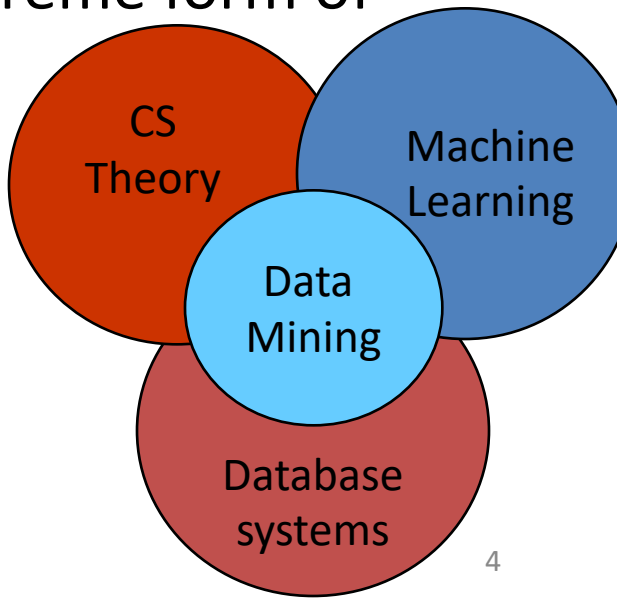
COURSE BACKGROUND

What is Data Mining?

- **Given lots of data**
- **Discover patterns and models that are:**
  - **Valid:** should hold on new data with some certainty
  - **Useful:** should be possible to act on the item
  - **Unexpected:** non-obvious to the system
  - **Understandable:** humans should be able to interpret the pattern

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!**

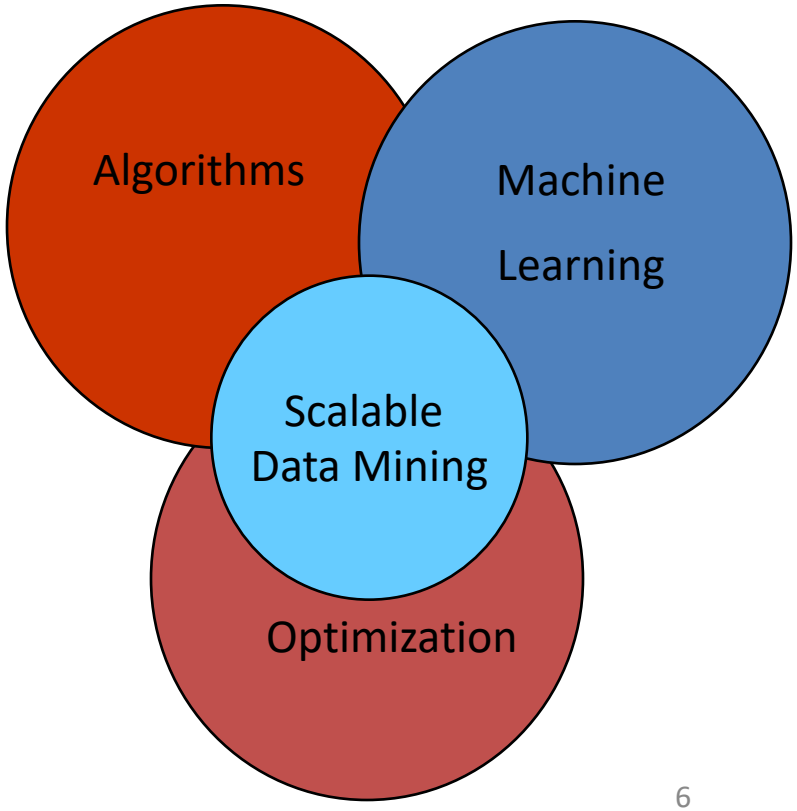


Need for Computing Frameworks

- To extract knowledge, data needs to be:
  - Stored
  - Managed
  - Analyzed
- For Big Data Computation: Spark
- For Deep Learning: Pytorch / Tensorflow

This Course

- **This class overlaps with machine learning, statistics, artificial intelligence, databases but more stress on**
  - **Algorithms**
    - **Online / Streaming**
    - **Optimization**
  - **Computing architectures**



Pre-requisites

- Algorithms.
- Machine Learning / Data Analytics / Information Retrieval.

What will we learn?

- **We will learn to mine different types of data:**
  - Data is high dimensional
  - Data is a graph
  - Data is infinite/never-ending
  - Data is labeled
- **We will learn to use different models of computation:**
  - MapReduce
  - Streams and online algorithms
  - Single machine in-memory
  - Distributed computation

What will we learn?

- **We will learn various "tools":**
  - Map-reduce, pytorch, tensorflow
  - Optimization (stochastic gradient descent)
  - Hashing (LSH, Bloom filters)

EXAMPLE APPLICATIONS

Word Count Distribution

- Compute word-bigram count distribution for wikipedia corpus.
- 5 million documents
- 1.9 million unique words, ? bigrams

- Problem: Input, output and intermediate results are large.
- Algorithm is simple.

Large Scale Machine Learning

- Train Massive deep learning models on massive datasets.
- Dataset too large:
  - Speed up train by speeding up optimization
  - Acceleration techniques
  - Distributed optimization.
- Model size too big:
  - Reduce redundant parameters using LSH
  - Change model architecture.

Distinct items

- Count number of distinct IP addresses passing through a server.
- Streaming model.
- Problem: 128^4 IP addresses

- We want only an estimate – FM sketch.

Locality Sensitive Hashing

- Active learning / Subset selection
  - Calculate pairwise similarity between examples
  - Select examples which provide highest improvement in loss function and are most similar to other non-selected examples.
- Compute similarity to all existing examples in dataset and pick the top ones.
  - Fast nearest neighbor seach.

Syllabus

- **Software paradigms:**
  - **Big Data Processing:** Motivation and Fundamentals. Map-reduce framework. Functional programming and Scala. Programming using map-reduce paradigm. Case studies: Finding similar items, Page rank, Matrix factorisation.
  - **Deep Learning Framework (Tensorflow / Pytorch):** Motivation, Tensors, Operations, Computation graphs, Example programs.

Syllabus

- **Optimization and Machine learning algorithms:**
  - **Optimization algorithms**: Stochastic gradient descent, Variance reduction, Momentum algorithms, ADAM. Dual-coordinate descent algorithms.
  - **Algorithms for distributed optimization:** Stochastic gradient descent and related methods. ADMM and decomposition methods, Federated Learning.

Syllabus

- **Algorithmic techniques:**
  - **Finding similar items:** Shingles, Minhashing, Locality Sensitive Hashing families.
  - **Stream processing:** Motivation, Sampling, Bloom filtering, Count-distinct using FM sketch, Estimating moments using AMS sketch.
  - **Dimensionality reduction:** Random projections, Johnson-Lindenstrauss lemma, JL transforms, sparse JL-transform.

COURSE DETAILS

Venue

- Classroom: MS Teams (Scalable Data Mining 2021)
- Slots:
  - Monday (8:00 - 9:55)
  - Tuesday (12:00 – 12:55)
- Website: http://cse.iitkgp.ac.in/~sourangshu/coursefiles/cs60021_2021a.html
- Moodle (for assignment submission): https://10.5.18.110/moodle

Teaching Assistants

- Soumi Das
- Kiran Purohit

Evaluation

- Grades:
  - Tests + Quiz: 50
  - Term Project: 30
  - Assignment: 20

- Number of Assignments: 2 – 4
- Both Term Project and assignment will require you to write code.