

$$\begin{bmatrix} \sigma_1 & & & \\ & \sigma_2 & & \\ & & \ddots & \\ 0 & & & \sigma_n \end{bmatrix}$$

$$X = \sum_{i=1}^{\text{rank}(X)} \sigma_i u_i v_i^T = U \Sigma V^T$$

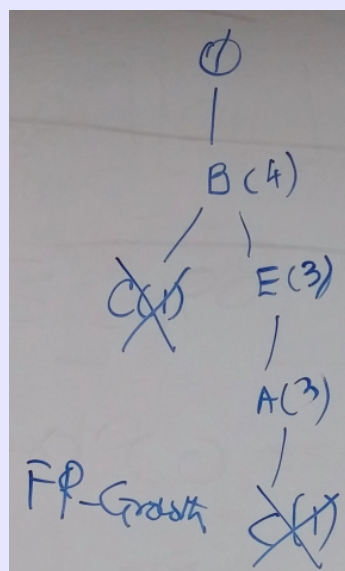
i^{th} singular value of X i^{th} left singular value of X (i^{th} column of U) i^{th} right singular vector of X (i^{th} column of V^T)

Captures the patterns among attributes
 Captures the patterns among the objects

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

CS 422: Data Mining
 Vijay K. Gurbani, Ph.D.,
 Illinois Institute of Technology

Lecture 1: Introduction



Introduction: Back to data mining

Is Data Mining a new field?

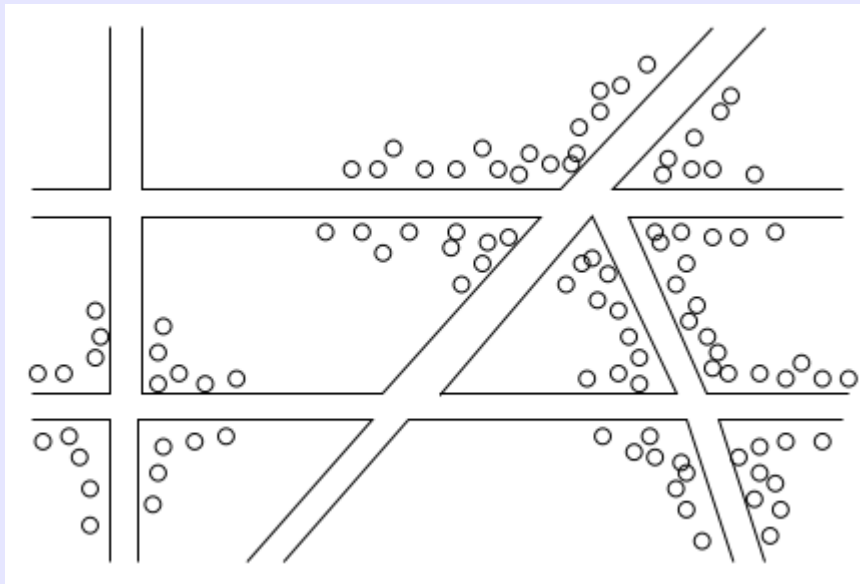


Figure source: Mining of Massive Datasets, Leskovec et al., 2014.

Introduction: Back to data mining

- Data mining vs. machine learning vs. ...
 - Data mining: a cross-disciplinary field focused on discovering properties (patterns) of (large, very large) data sets.
 - How does it do this?
 - Machine learning is one approach.

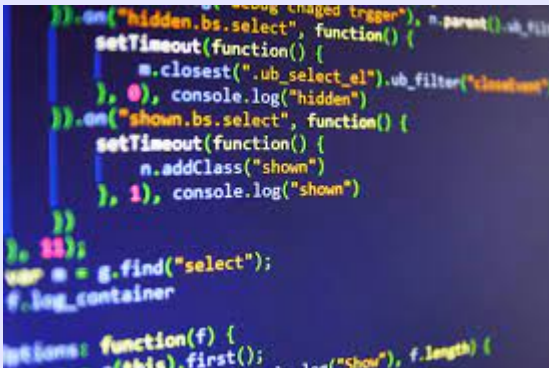
Introduction: Back to data mining

- Machine learning is all around us.
 - Netflix
 - Google
 - Amazon, ...
- You've all heard the fantastic stories of self-driving cars, mood-sensing environment, why diapers and beer go together, what Target knows about you, and so on ?

Data mining and machine learning

Computer Science

- Determinism rules.



```
)).on("hidden.bs.select", function() {  
    setTimeout(function() {  
        m.closest(".ub_select_el").ub_filter("closedown")  
    }, 0), console.log("hidden")  
}).on("shown.bs.select", function() {  
    setTimeout(function() {  
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    }, 1), console.log("shown")  
})  
}).11);  
var = g.find("select");  
f.log_container  
ptions: function(f) {  
    (this).first();  
    log("Show", f.length) }
```

Machine Learning

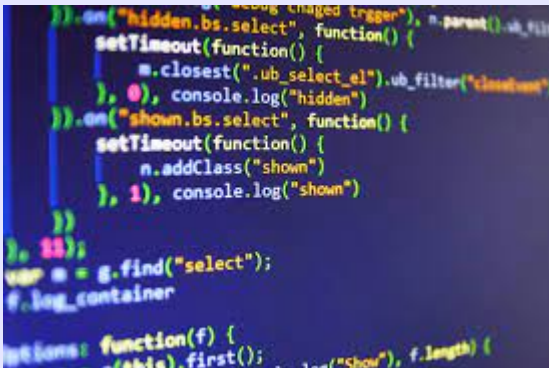
- Generalization is key.



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Machine Learning

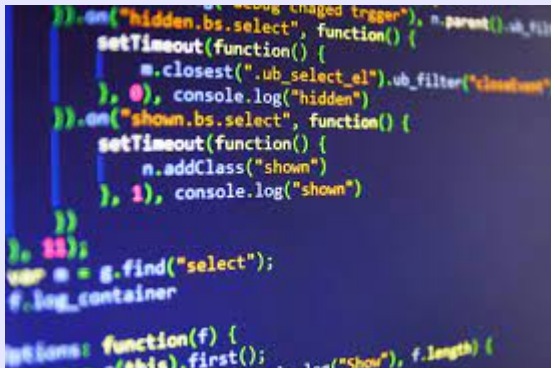
- Generalization is key.
- Errors part of the landscape.



Data mining and machine learning

Computer Science

- Determinism rules.
- Errors not tolerated.
- Algorithms do not learn.



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```

Machine Learning

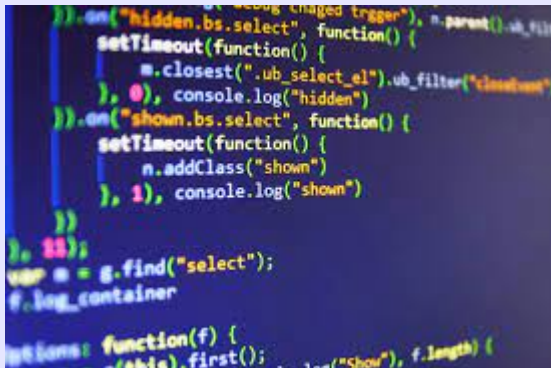
- Generalization is key.
- Errors part of the landscape.
- Algorithms learn (backprop, genetic programming).



Data mining and machine learning

Computer Science

- Determinism rules.
- Errors not tolerated.
- Algorithms do not learn.
- $\text{Program(Data)} \Rightarrow \text{Output}$. Program most important artifact.



Machine Learning

- Generalization is key.
- Errors part of the landscape.
- Algorithms learn (backprop, genetic programming).
- $\text{Data}(\text{Program}) \Rightarrow \text{Model} \Rightarrow \text{Output}$.
Data most important artifact.



Data mining and machine learning

- The Machine Learning Problem: *Generalizing to cases we have not seen before.*
- But, can't we simply see all or most of the data?

Data mining and machine learning

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- But, can't we simply see all or most of the data?
- Suppose: You have data that consists of 1,000 Boolean fields, and you have 1,000,000,000,000 records in a database.
- How much insight do these 1 trillion records represent?

Data mining and machine learning

- The Machine Learning Problem: *Generalizing to cases we have not seen before.*
- But, can't we simply see all or most of the data?
- Suppose: You have data that consists of 1,000 Boolean fields, and you have 1,000,000,000,000 records in a database.
- How much insight do these 1 trillion records represent?
- Theoretically, you will need 2^{1000} records to represent all of your data!!
- **How big is 2^{1000} ?**
 - $2^{1000} \approx 1.07^{301} \approx 10^{301}$.
 - 10^{18} grains of sand in the world.
 - 10^{22} stars in the observable universe.
 - 10^{78} atoms in the observable universe.

- The 1 trillions records are one “gazillionth*” of 1 percent of 2^{1000} !
* Gazillionth = $10e-285$
- Morals:
 - Curse of dimensionality is real
 - Generalization is how we deal with combinatorial explosion!

Resources

- Conferences in data mining and machine learning (non-exhaustive)
 - ACM KDD (Knowledge Discovery and Data Mining), <http://www.kdd.org>
 - ICML (International Conference on Machine Learning)
 - ACM CIKM (International Conference on Information and Knowledge Management)
 - SDM (SIAM International Conference on Data Mining)
 - NeurIPS
- Journals (non-exhaustive)
 - IEEE Transactions on Pattern Analysis and Machine Intelligence
 - ACM Transactions on Knowledge Discovery from Data
 - IEEE Transactions on Knowledge and Data Engineering

Resources

- Useful general Internet resources on data mining and machine learning:
 - Kaggle (<https://www.kaggle.com>)
 - Kdnuggets (<https://www.kdnuggets.com>)
 - <https://machinelearningmastery.com>
 - <https://towardsdatascience.com>