Introduction to Machine Learning: CS 436/580L

Introduction

Instructor: Arti Ramesh

Binghamton University

Logistics

- **Instructor: Arti Ramesh**
  - Email: artir@binghamton.edu
  - Office: N-4 Engineering Building
  - Office hours: Tuesdays/Thursdays – 2:45 p.m. to 3:45 p.m.
- **TA: Gissella Bejarano**
  - Email gbejara1@binghamton.edu
  - Office Hours: Mondays/Wednesdays – 10:00 am to 11:00 am
- **Course available now on myCourses**
- **Long Programming course**

Grading

- Around Five-Six homeworks (**40%**)
  - 8-10% each
  - Due one-two weeks later
  - Some programming, some exercises
  - Assigned via myCourses.
- One Midterm (**20%**), One Comprehensive Final (**25%**)
  - Exams are closed book. You will be allowed a cheat sheet, a double-sided 8.5 x 11 page.

Grading

- In-class Quizzes (**10%**)
  - One big quiz before midterm (late September), 3-4 smaller quizzes
  - Quizzes are closed book and closed notes. No cheat sheets allowed.
- Class Participation (**5%**)
  - based on attendance and how actively a student participates in class discussions.
- Attendance, attention, and participation is mandatory
  - Grade reduced by a letter grade for lack of attendance (e.g., A- becomes B-; B- becomes a C-; etc)

Source Materials

- T. Mitchell, ***Machine Learning,*** McGraw-Hill (required)
- C. Bishop, **Pattern Recognition and Machine Learning**, Springer (required)
- Kevin Murphy, **Machine Learning: A probabilistic perspective** (recommended)
- Class Notes/Slides

Administrivia

- HW 0 will be available after Tuesday's class
  - On course prerequisites – probability and statistics
  - Worth 5 points out of 40 total homework points
  - Due on Sep 6th, 11:59 pm ET (tentative date, will be changed depending on class changes due to students adding/dropping from the course)

Class Activity

- Discuss with your neighbor
- What do you think is machine learning? Define in your own words.
- Think of one task you think that is already using/ could greatly benefit from machine learning.

  E.g., self-driving cars!

Be creative!!! I would like as many different answers as possible!!!

Introducing Machine Learning

Play video:

https://www.ted.com/talks/kenneth_cukier_big_data_is_better_data#t-729970

Glassdoor: Data Scientist Jobs

25 Best Jobs in America

7.6k
Shares

Want a new job? Glassdoor is here to help, identifying the 25 Best Jobs in America for 2016. The jobs that make this list have the highest overall Glassdoor Job Score, determined by combining three key factors – number of job openings, salary and career opportunities rating. These jobs stand out across all three categories.

United States ▾ 2016 ▾

1

Data Scientist

Job Openings	**1,736**
Median Base Salary	**$116,840**
Career Opportunity	**4.1**
Job Score	**4.7**

Help Wanted: Black Belts in Data

Starting salaries for data scientists have gone north of $200,000

by Rodrigo Orihuela and Dina Bass
from **Bloomberg Businessweek**

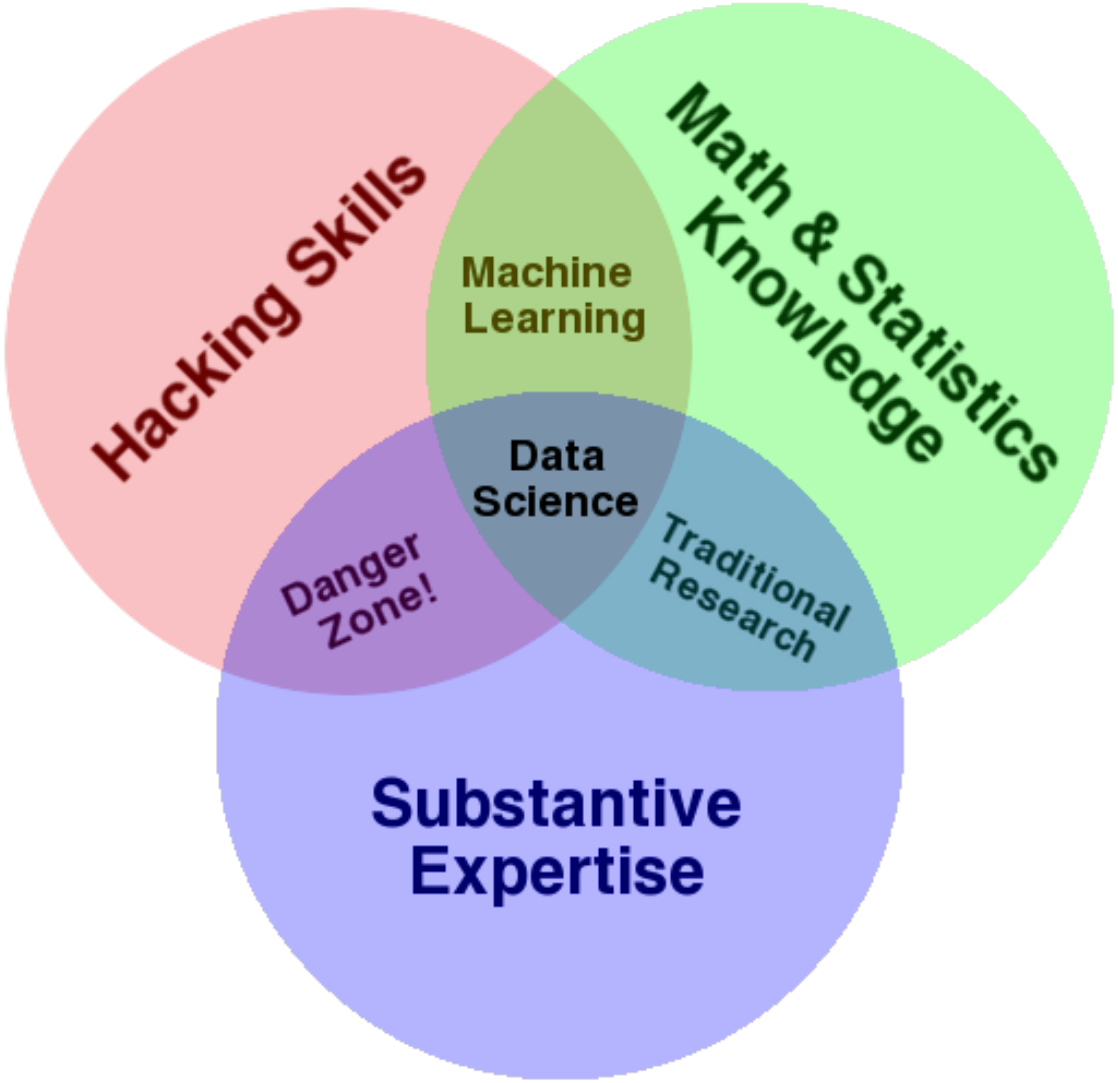
June 4, 2015 – 1:07 PM EDT *Updated on* June 4, 2015 – 2:00 PM EDT

Photographer: Getty Images

A new species of techie is in demand these days—not only in Silicon Valley, but also in company headquarters around the world. "Data scientists are the new superheroes," says Pascal Clement, the head of Amadeus Travel Intelligence in Madrid. The description isn't exactly hyperbolic. The qualifications for the job include the strength

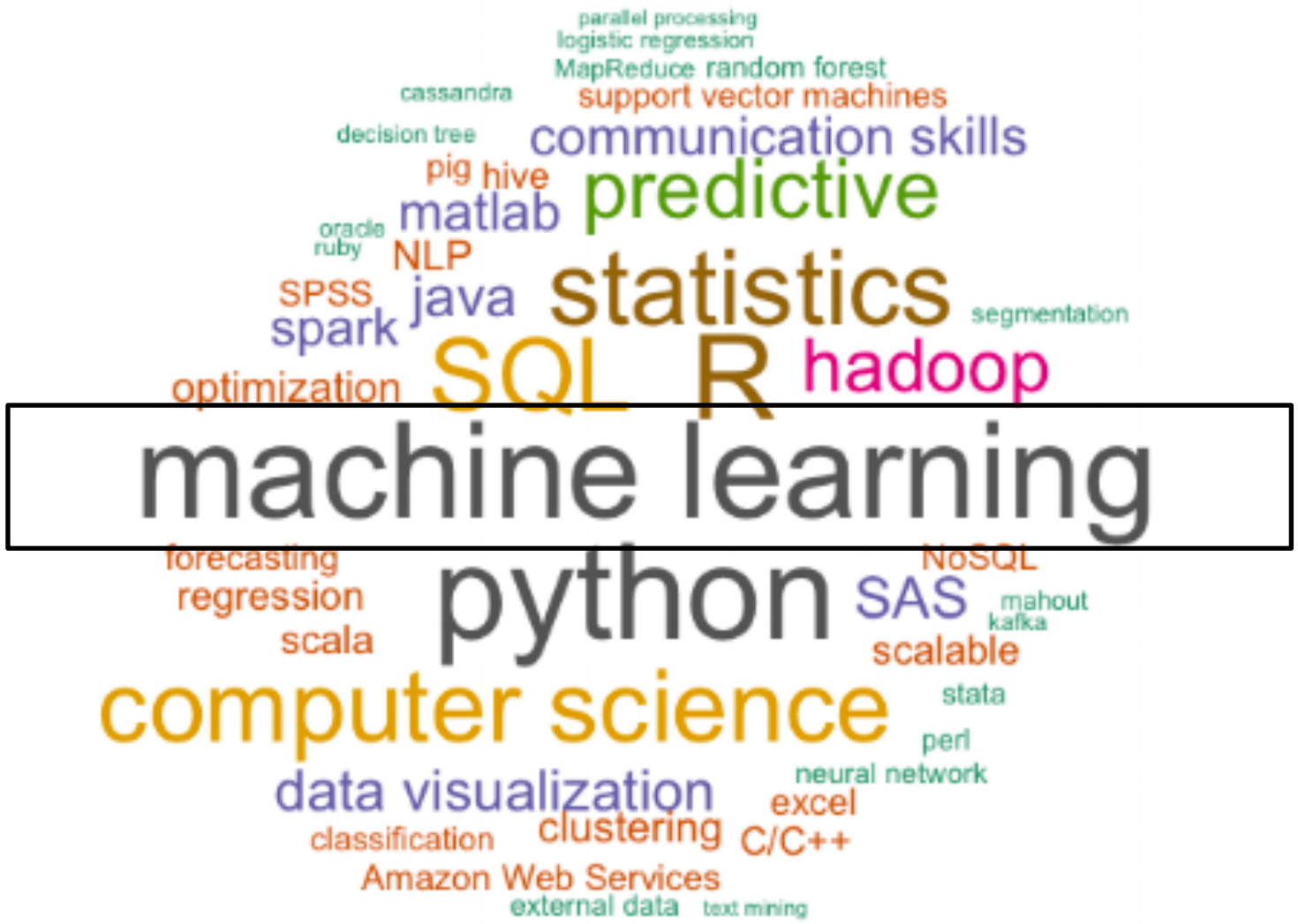
http://www.bloomberg.com/news/articles/2015-06-04/help-wanted-black-belts-in-data

What is Data Science?



Most Important Technical Skills for Data Science

Most Important Technical Skills for Data Science

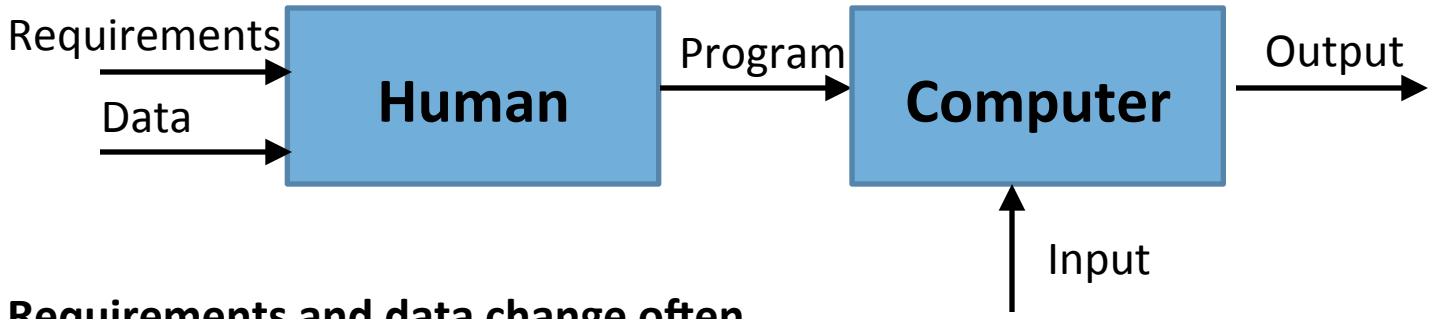


Why Study Machine Learning: A Few Quotes

- "A breakthrough in machine learning would be worth ten Microsofts" (Bill Gates, Microsoft)
- "Machine learning is the next Internet" (Tony Tether, Former Director, DARPA)
- Machine learning is the hot new thing" (John Hennessy, President, Stanford)
- "Web rankings today are mostly a matter of machine learning" (Prabhakar Raghavan, Former Dir. Research, Yahoo)
- "Machine learning is going to result in a real revolution" (Greg Papadopoulos, CTO, Sun)

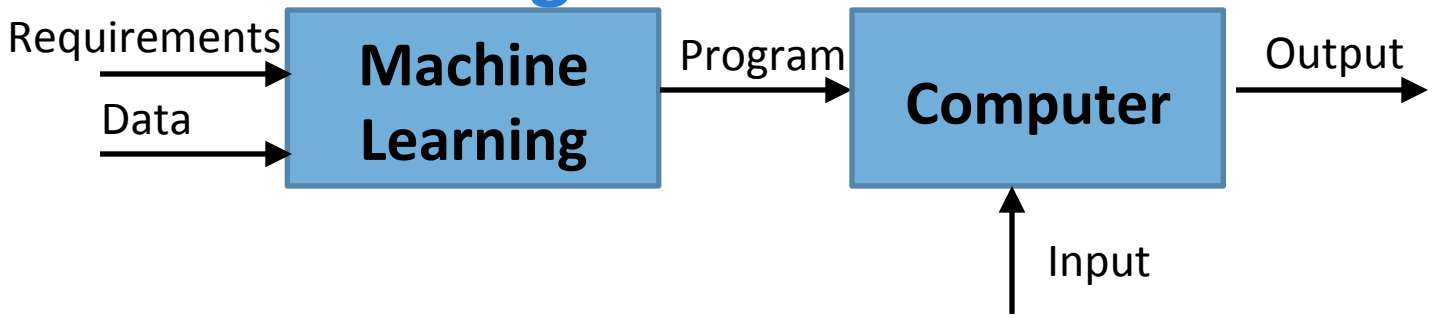
- Getting computers to program themselves
- Writing software is the bottleneck, let data do the work

Traditional Programming



Requirements and data change often

Machine Learning



Training Data

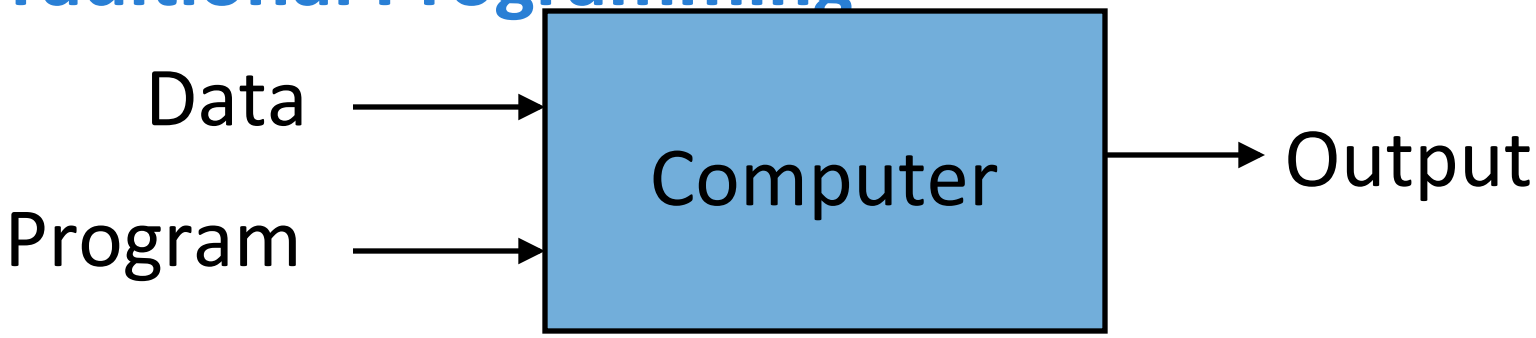
Training Example

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes
D11	Sunny	Mild	Normal	Strong	Yes
D12	Overcast	Mild	High	Strong	Yes
D13	Overcast	Hot	Normal	Weak	Yes
D14	Rain	Mild	High	Strong	No

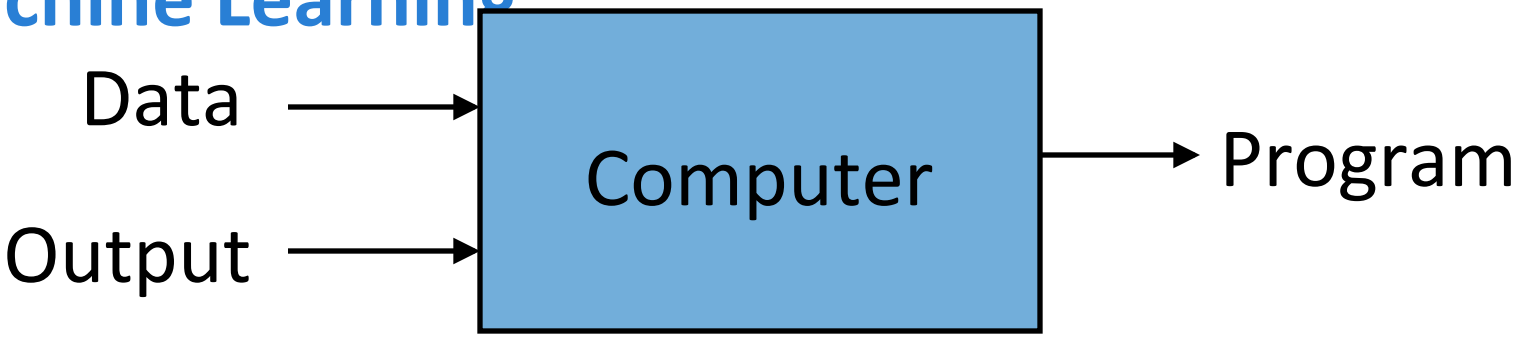
Two Classes: {Yes,No}

- Getting computers to program themselves
- Writing software is the bottleneck, let data do the work

Traditional Programming



Machine Learning



Magic?

No, more like gardening

- **Seeds** = Algorithms
- **Nutrients** = Data
- **Gardener** = You
- **Plants** = Programs

Definition: Machine Learning!

- T. Mitchell: Well posed machine learning
  - Improving performance via experience
  - Formally, A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, it its performance at tasks in T as measured by P, improves with experience.
- H. Simon
  - Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the task or tasks drawn from the same population more efficiently and more effectively the next time.

The ability to perform a task in a situation which has never been encountered before

Example 1: A Chess learning problem

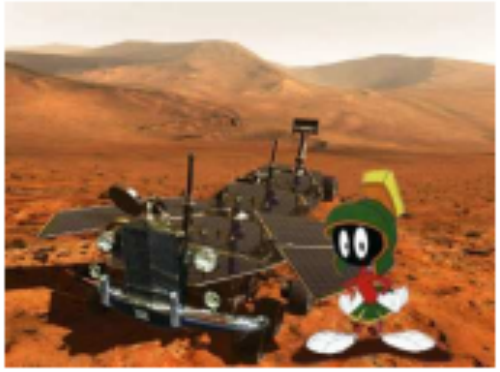
- Task T: playing chess
- Performance measure P: percent of games won against opponents
- Training Experience E: playing practice games against itself

Example 2: Autonomous Vehicle Problem

- Task T: driving on a public highway/roads using vision sensors
- Performance Measure P: percentage of time the vehicle is involved in an accident
- Training Experience E: a sequence of images and steering commands recorded while observing a human driver

When to use Machine Learning?

- Human expertise is absent
  - Example: navigating on mars
- Humans are unable to explain their expertise
  - Example: vision, speech, language
- Requirements and data change over time
  - Example: Tracking, Biometrics, Personalized fingerprint recognition
- The problem or the data size is just too large
  - Example: Web Search



Types of Learning

- **Supervised (inductive) learning**
  - Training data includes desired outputs
- **Unsupervised learning**
  - Training data does not include desired outputs
  - Find hidden/interesting structure in data
- **Semi-supervised learning**
  - Training data includes a few desired outputs
- **Reinforcement learning**
  - the learner interacts with the world via “actions” and tries to find an optimal policy of behavior with respect to “rewards” it receives from the environment

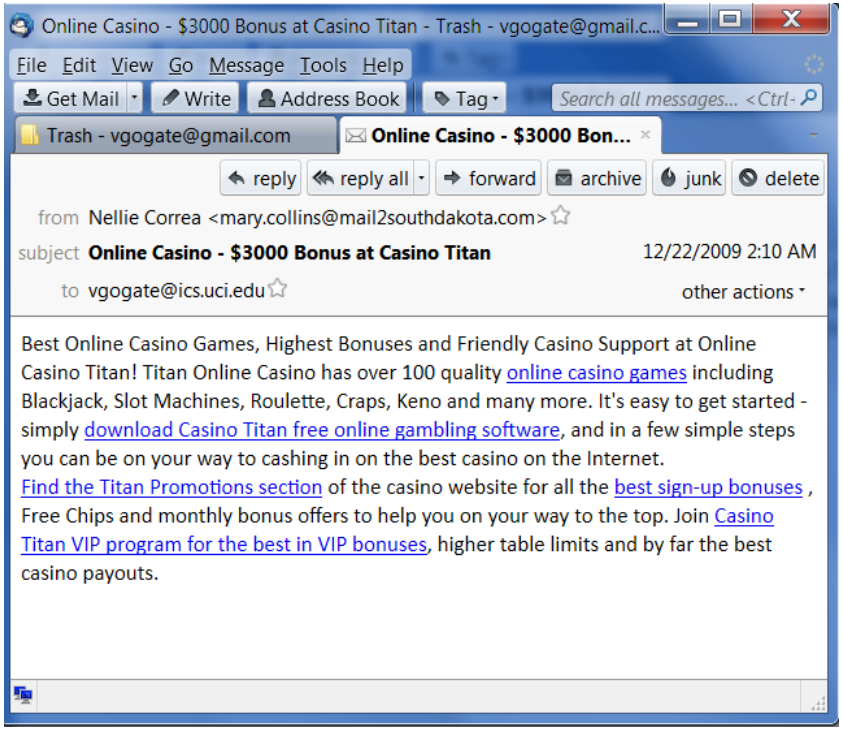
Examples/Types of Machine Learning Tasks

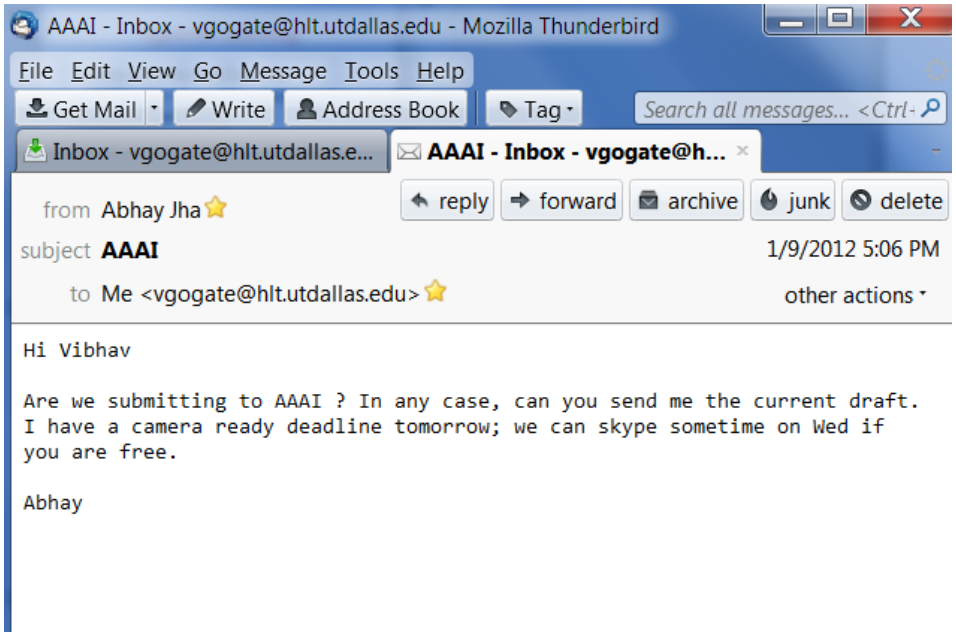
- Forecasting or Prediction
  - Stock price of Google tomorrow?
- Classification and Regression
  - Is Ana credit-worthy?
  - What is Ana's credit score?
- Ranking
  - How to rank images that contain "An awesome machine learning model"?
- Outlier/Anomaly/Fraud detection
  - Is it Ana" using the credit card in Mexico or is it someone else?
- Finding patterns
  - Almost 60% of shoppers buy Diapers and Milk together!

Machine Learning: Applications

- Examples of real-world scenarios where machine learning performs its magic!

Classification Example: Spam Filtering





Classify as “Spam” or “Not Spam”

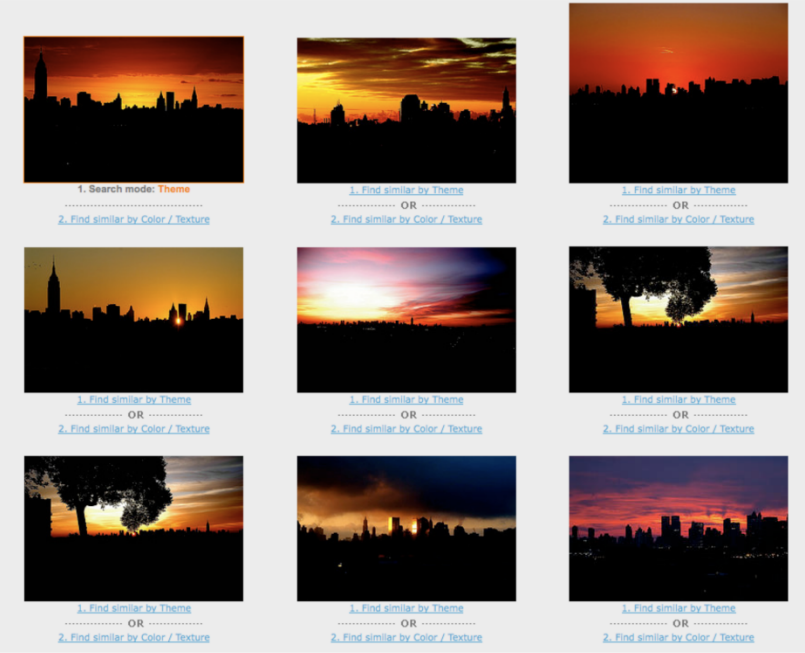
Classification Example: Weather Prediction

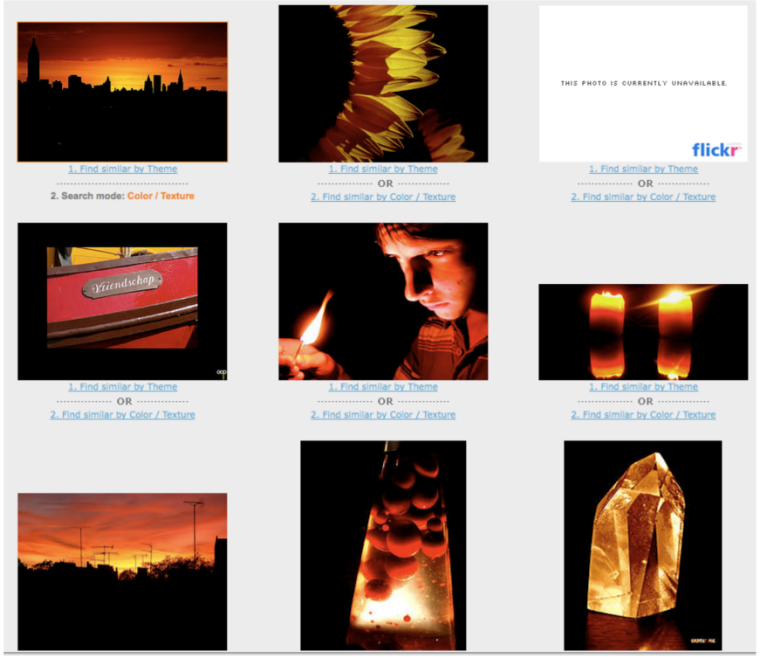
Regression example: Predicting Gold/ Stock prices

Good ML can make you rich (but there is still some risk involved).

Given historical data on Gold prices, predict tomorrow's price!

Similarity Determination

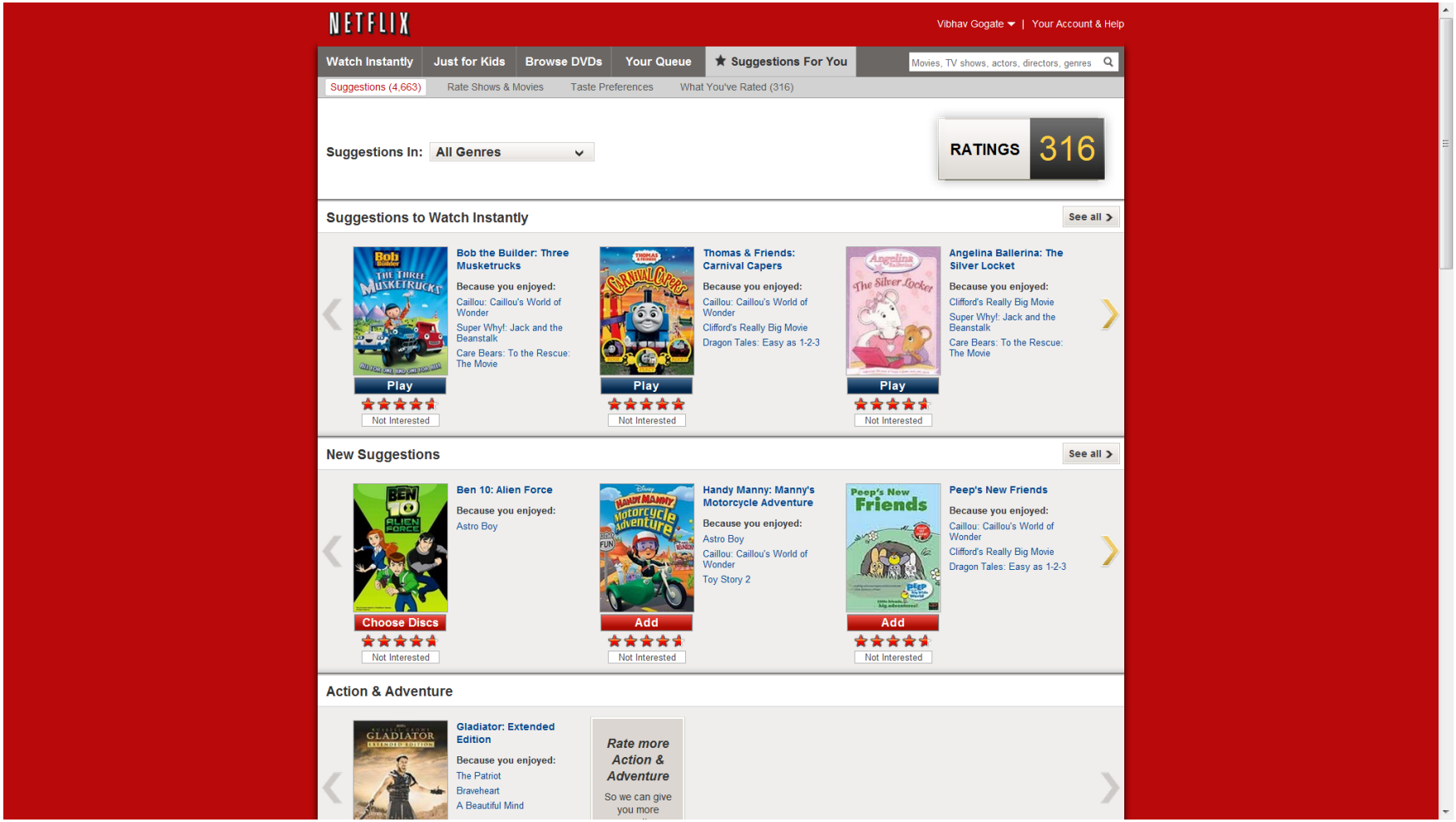




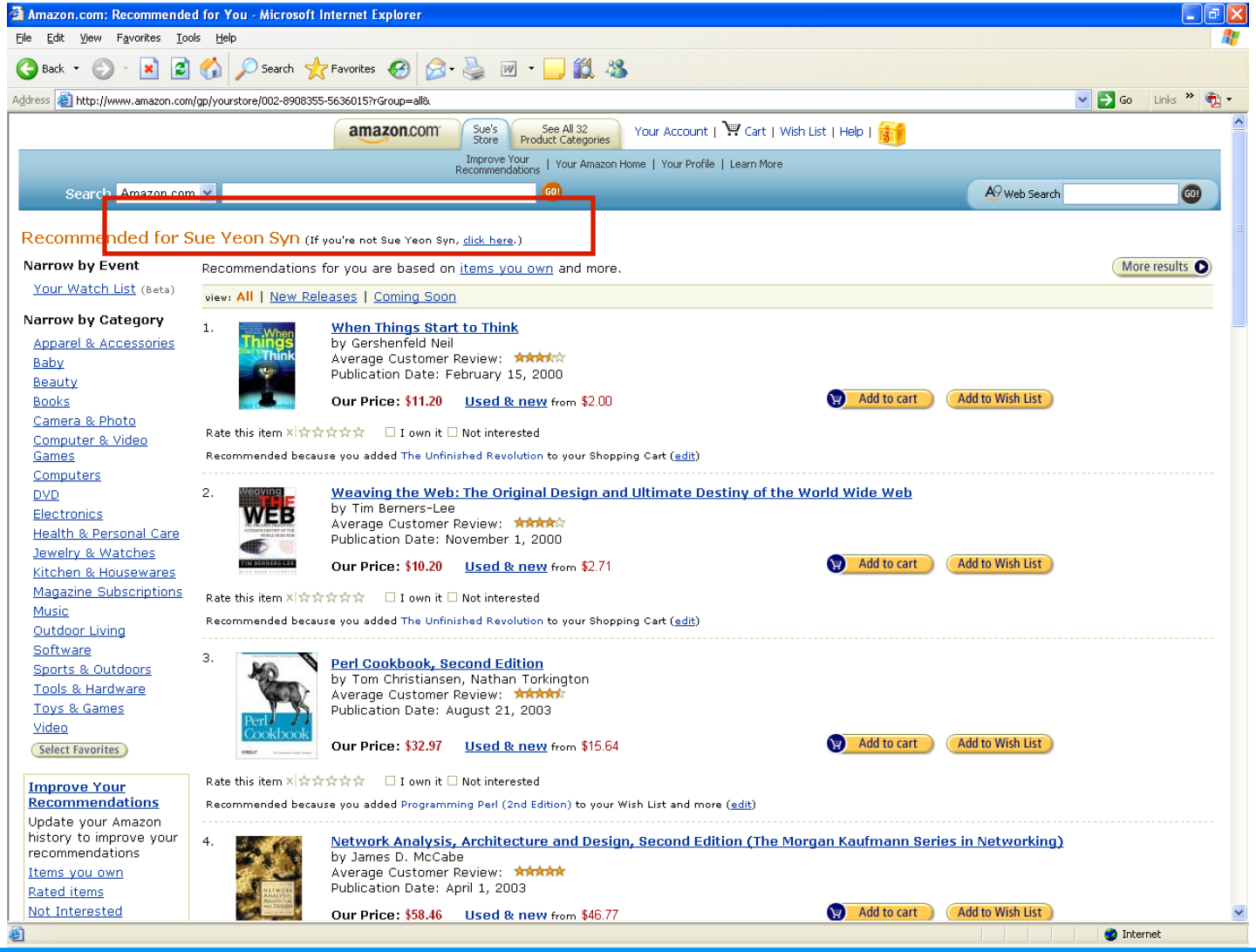
Collaborative Filtering

- *The problem of collaborative filtering is to predict how well a user will like an item that he has not rated given a set of historical preference judgments for a community of users.*

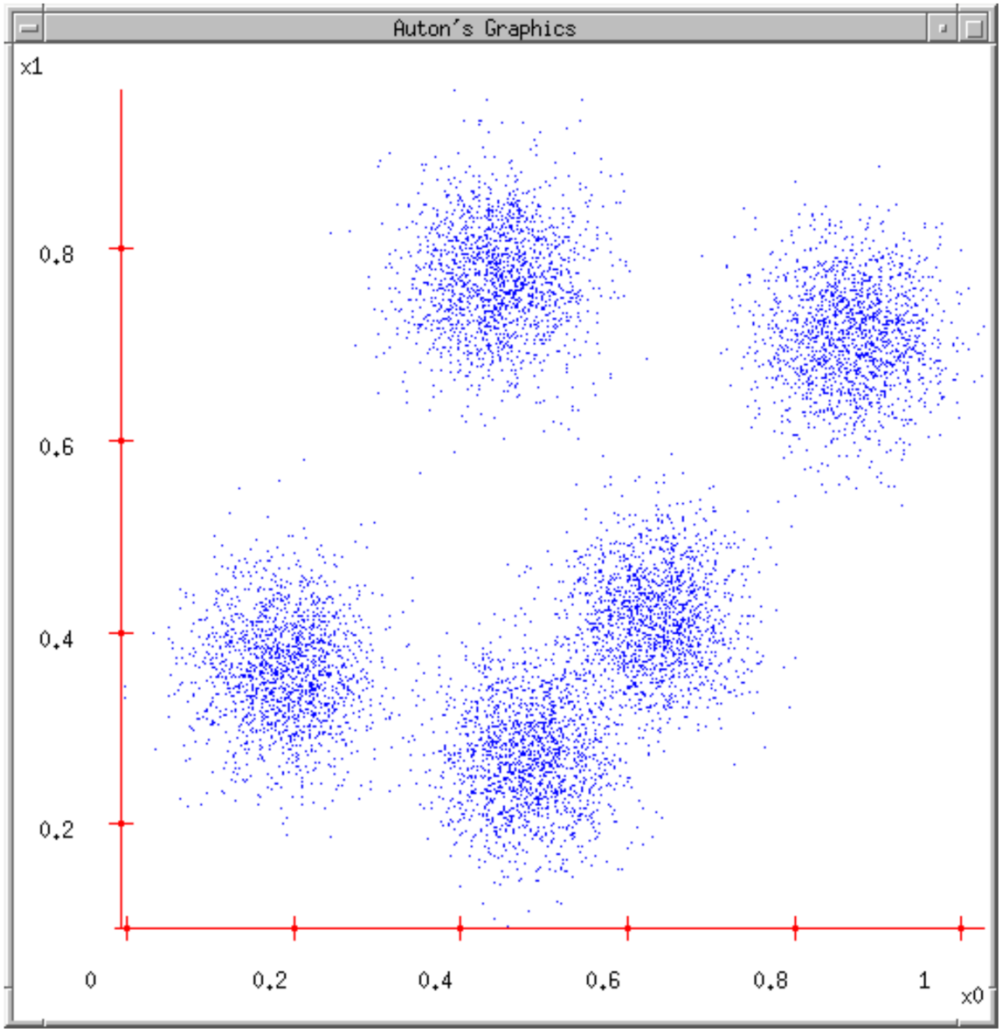
Collaborative Filtering



Collaborative Filtering

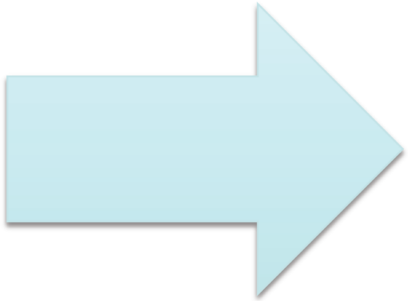


Clustering: Discover Structure in data



Clustering

Clustering images



[Goldberger et al.]

ML in a Nutshell

- Tens of thousands of machine learning algorithms
- Hundreds new every year
- Every machine learning algorithm has three components:
  - **Representation**
  - **Evaluation**
  - **Optimization**

Representation

- Decision trees
- Sets of rules / Logic programs
- Instances
- Graphical models (Bayes/Markov nets)
- Neural networks
- Support vector machines
- Model ensembles
- Etc.

Evaluation

- Accuracy
- Precision and recall
- Squared error
- Likelihood
- Posterior probability
- Cost / Utility
- Margin
- Entropy
- K-L divergence
- Etc.

Optimization

- Combinatorial optimization
  - E.g.: Greedy search
- Convex optimization
  - E.g.: Gradient descent
- Constrained optimization
  - E.g.: Linear programming

Machine learning has grown in leaps and bounds

- The main approach for
  - Speech Recognition
  - Robotics
  - Natural Language Processing
  - Computational Biology
  - Sensor networks
  - Computer Vision
  - Web
  - And so on

Alice/Bob says: I know machine learning very well!

Potential Employer: You are hired!!!

What We'll Cover

- **Supervised learning:** Decision tree induction, Rule induction, Instance-based learning, Bayesian learning, Neural networks, Support vector machines, Linear Regression, Model ensembles
- **Unsupervised learning:** Clustering, Dimensionality reduction
- **General machine learning concepts and techniques**: Feature selection, cross-validation, maximum likelihood estimation, gradient descent, expectation-maximization
- **And some special topics (if time permits)**: probabilistic graphical models, topic models
- **Your responsibility:**
  - **Brush up on some important background**
  - **Linear algebra, Statistics 101, Vectors, Probability theory**