Introduction to Machine Learning

WQD7006: Machine Learning for Data Science

Semester II, Session 2021/2022

Data Science

Multidisciplinary blend of **data inference, algorithm development, and technology** in order to solve **analytically** complex problems.

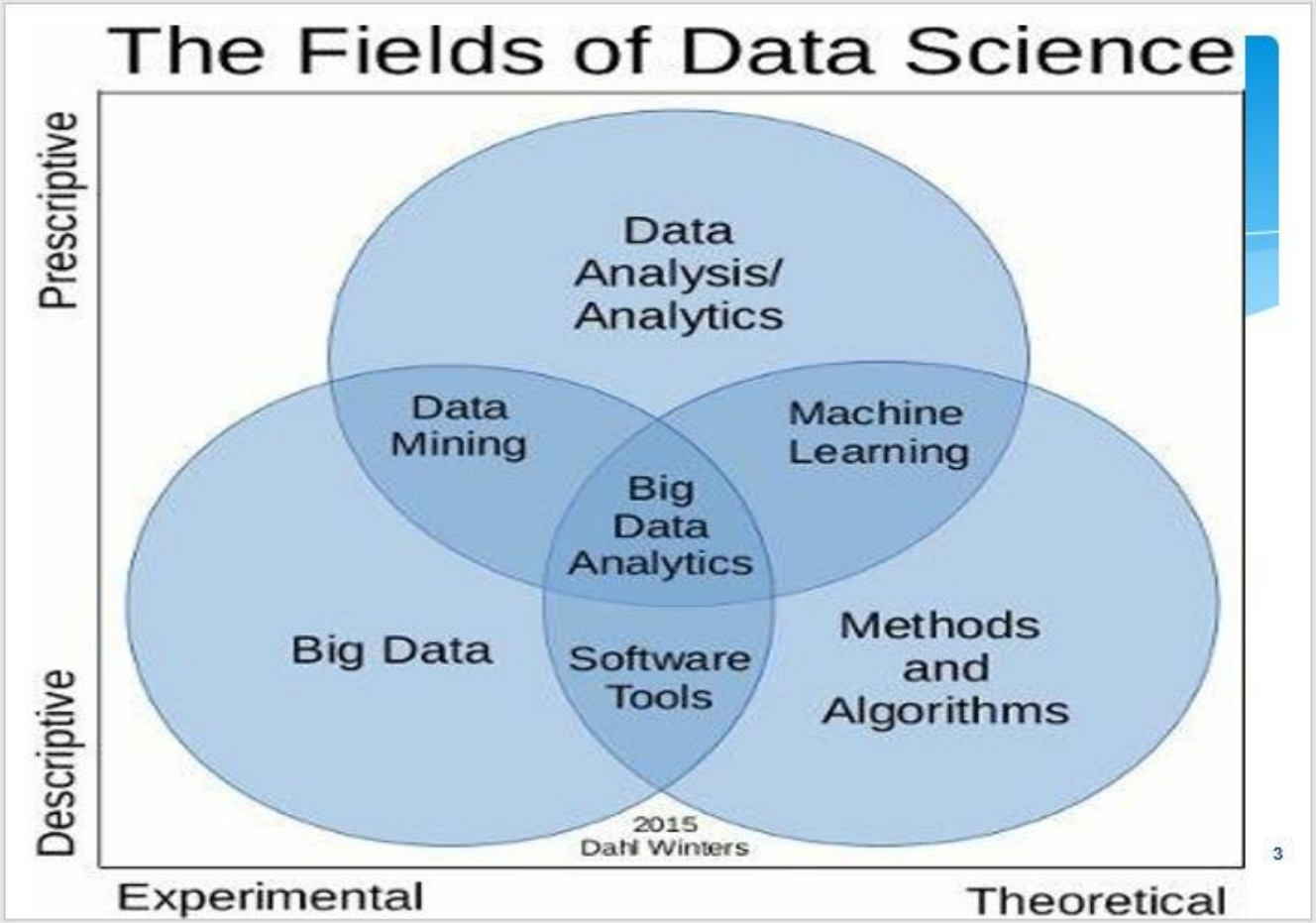
Multidisciplinary field that uses **scientific methods, processes, algorithms and systems** to extract **knowledge** and **insights** from data in various forms, **both structured and unstructured**

Data Scientist

“Someone who can **obtain, scrub, explore, model and interpret data, blending hacking, statistics and machine learning**”

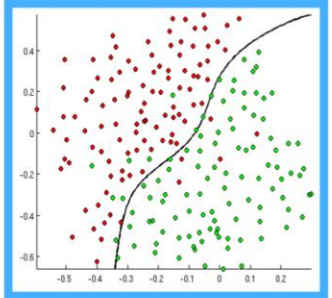
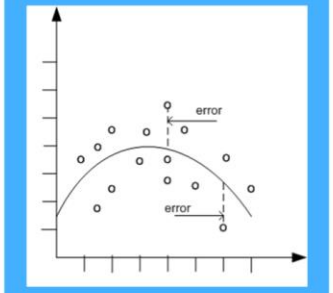
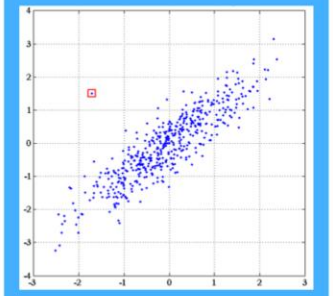
-- Hilary Mason, chief scientist at bit.ly

Data Science & Machine Learning?



Data Science & Machine Learning?

Advanced Analytics Questions Answered by "Data Science"

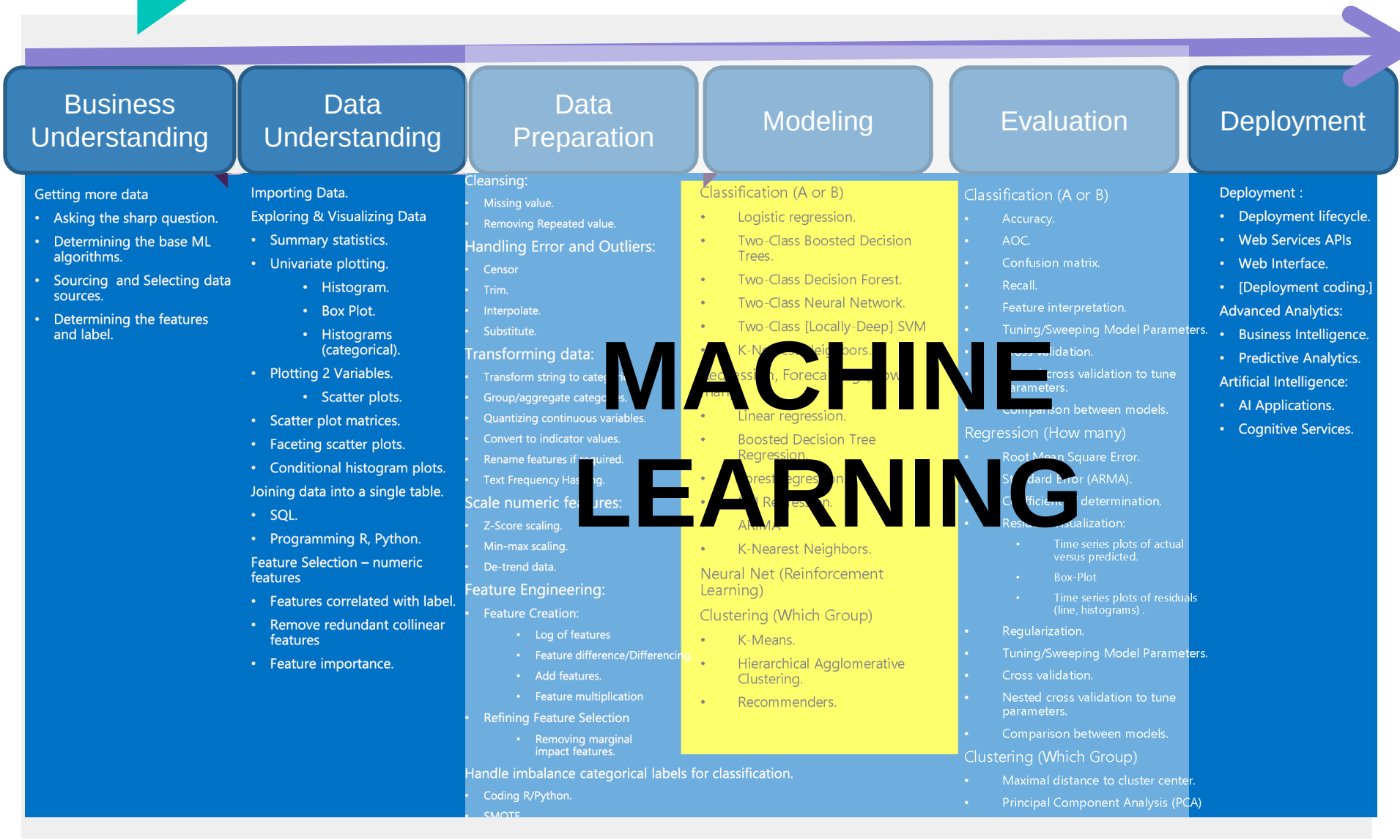
Classification	Regression (Forecasting)	Reinforcement Learning	Anomaly Detection	Clustering
				
Is it A or B? *e.g Will the HDD fail next month? Yes/No.*	**How much/how many?** *e.g. what is the temperature next Tuesday?*	**Which option?** *e.g. do the car stop or go on an orange light.*	**Is it weird?** *e.g. Fraud Detection.*	**Which groups?** *e.g. which viewers like the same type of movie.*

Machine Learning *algorithms are used in Advanced Analytics by Data Scientists.*

Data Science & Machine Learning?

Data is cheap and abundant,
knowledge is expensive and scarce.

‘Where’ is Machine Learning in Data Science?

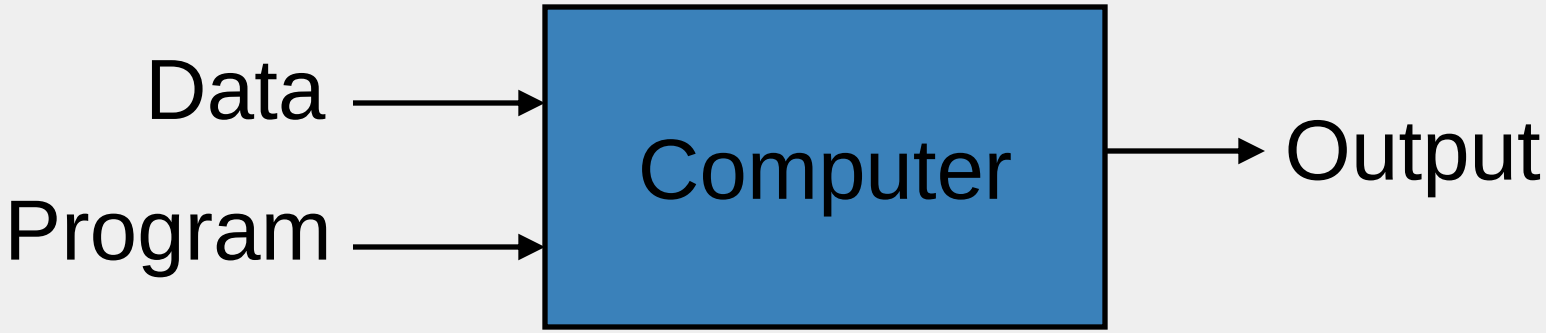


2. What is Machine Learning?

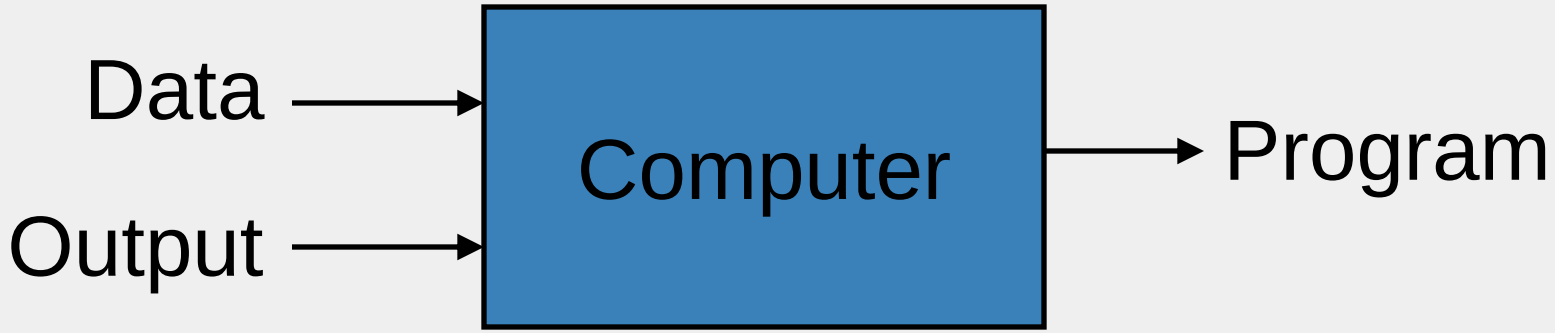
Generally and specifically

Machine Learning

Traditional Programming



Machine Learning



Applications of Machine Learning

- ***Database mining***

Large datasets from growth of automation/web.
E.g., Web click data, medical records, biology, engineering

- ***Applications & automation***

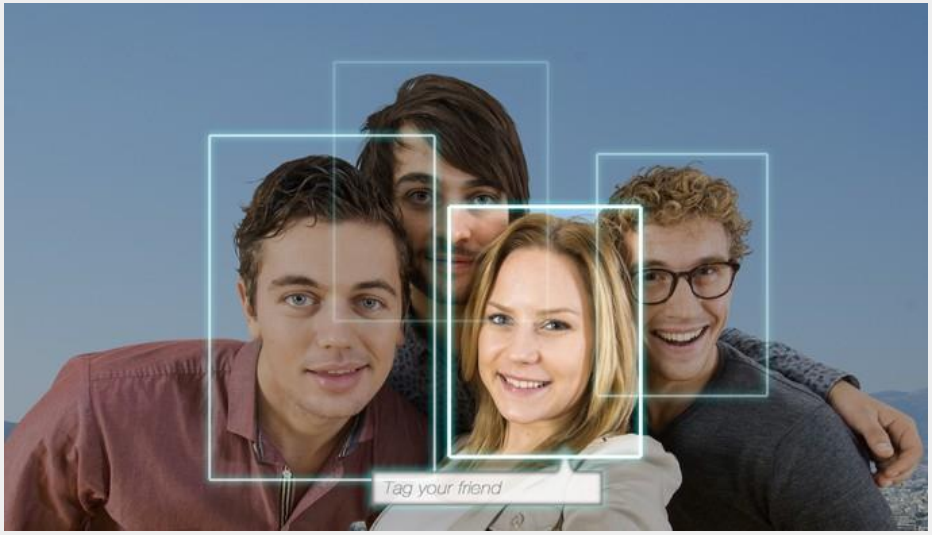
E.g., Autonomous helicopter, handwriting recognition, most of Natural Language Processing (NLP)

- ***Self-customizing programs***

E.g., Amazon, Netflix product recommendations

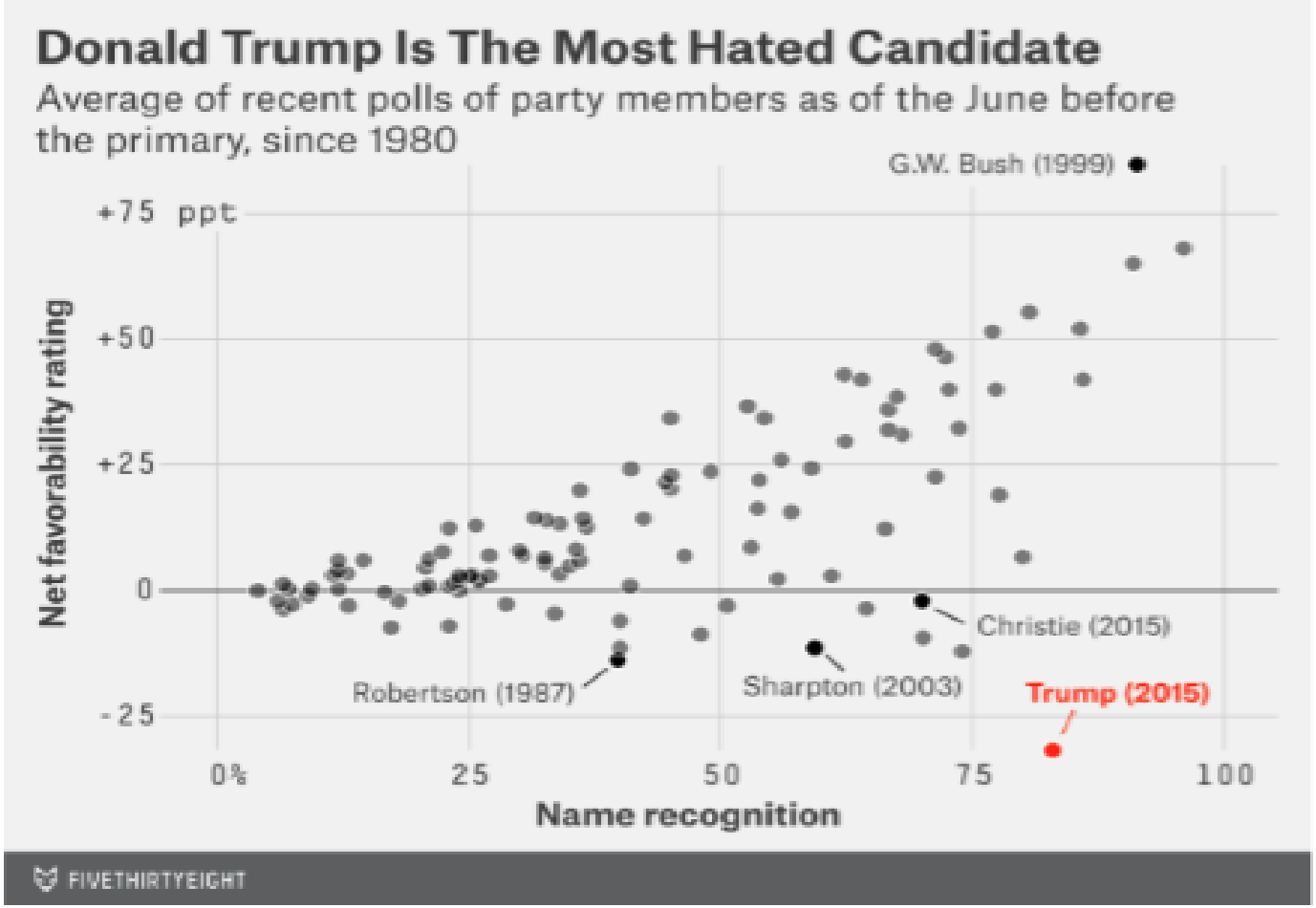
- ***Understanding human learning*** (robotics).

Applications of Machine Learning



ELECTION 2016

"Why Donald Trump Isn't A Real Candidate, In One Chart" (June 2015)



http://fivethirtyeight.com/datalab/why-donald-trump-isnt-a-real-candidate-in-one-chart/

Definition of Machine learning

- Arthur Samuel (1959). Machine Learning:

*Field of study that gives **computers** the ability to **learn** without being explicitly programmed.*

- Tom Mitchell (1998)

Well-posed Learning Problem:

*A computer program is said to learn from **experience E** with respect to some **task T** and some **performance** measure **P**, if its performance on T, as measured by P, improves with experience E.*

#Checkpoint

"A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E."

Suppose your email program watches which emails you do or do not mark as spam, and based on that learns how to better filter spam. What is the task T in this setting?

- ❑ Classifying emails as spam or not spam.
- ❑ Watching you label emails as spam or not spam.
- ❑ The number (or fraction) of emails correctly classified as spam/not spam.
- ❑ None of the above—this is not a machine learning problem.

Machine learning in a nutshell

- Every machine learning algorithm has three components:

Representation – decision trees, rules, neural networks, ensemble methods etc.

Evaluation – precision, recall, AUC, likelihood etc.

Optimization –

- Combinatorial optimization

E.g.: Greedy search

- Convex optimization

E.g.: Gradient descent

- Constrained optimization

E.g.: Linear programming

Types of Learning Algorithms

Machine learning algorithms:

- Supervised (inductive) learning (task driven)
  - Training data with desired outputs
  - Prediction
  - Classification (discrete labels), Regression (real values)

- Unsupervised learning (data driven)

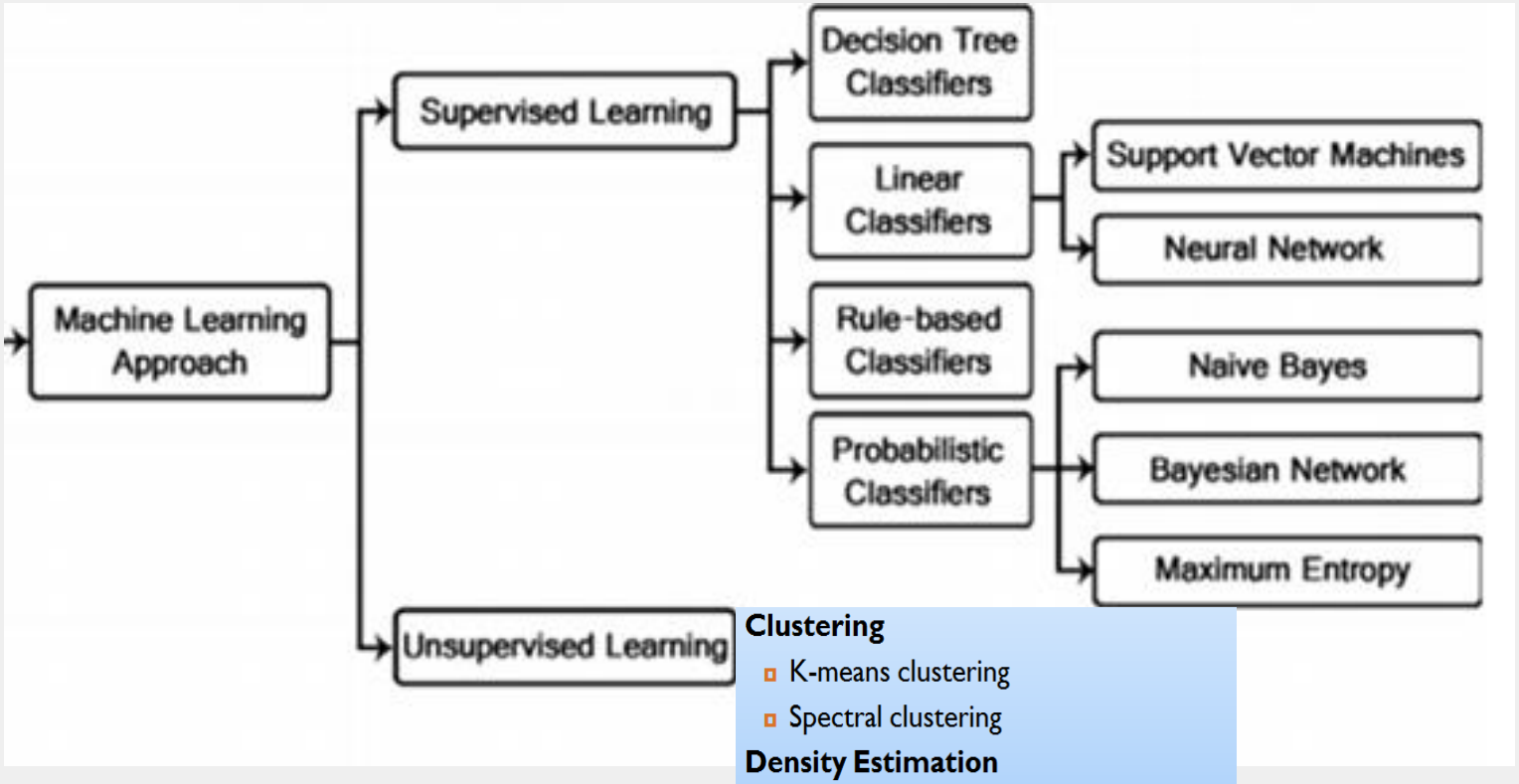
Training data without desired outputs
Clustering
Probability distribution estimation
Finding association (in features)
Dimension reduction

Types of Learning Algorithms

Machine learning algorithms:

- Semi-supervised
  - Training data with a few desired outputs
- Others:
  - Reinforcement learning (delayed reward), decision making (robot, chess game)
  - Recommender systems.

Types of Learning Algorithms



Clustering
- K-means clustering
- Spectral clustering

Density Estimation
- Gaussian mixture model (GMM)
- Graphical models

Dimensionality reduction
- Principal component analysis (PCA)
- Factor analysis

Medhat et al., 2014

3. Introduction to Supervised Learning

Supervised?

Supervised Learning and Regression

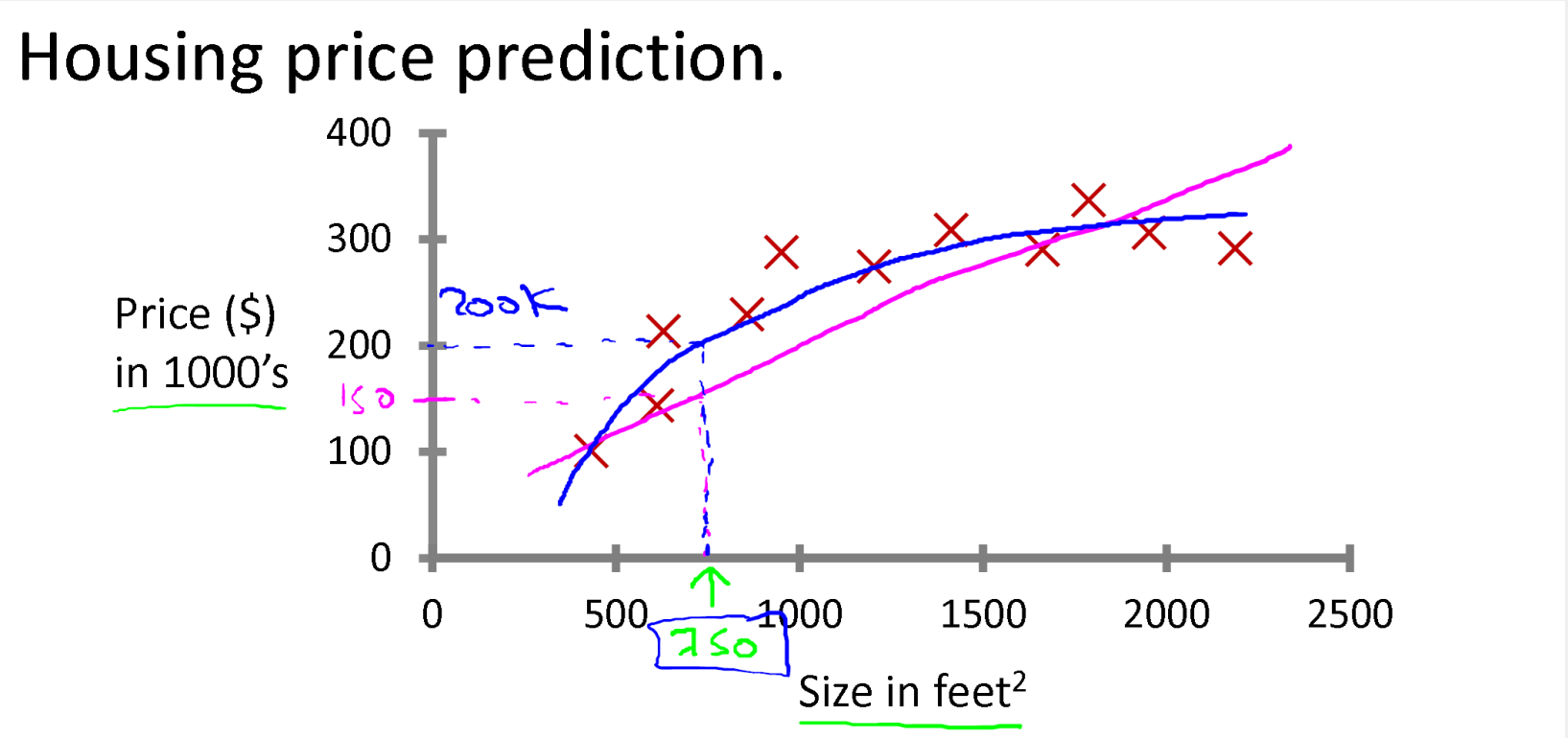
Given examples of a function *(X, F(X))*

Predict function *F(X)* for new examples *X*

Discrete *F(X)*: Classification
Continuous *F(X)*: Regression

F(X) = Probability(*X*): Probability estimation

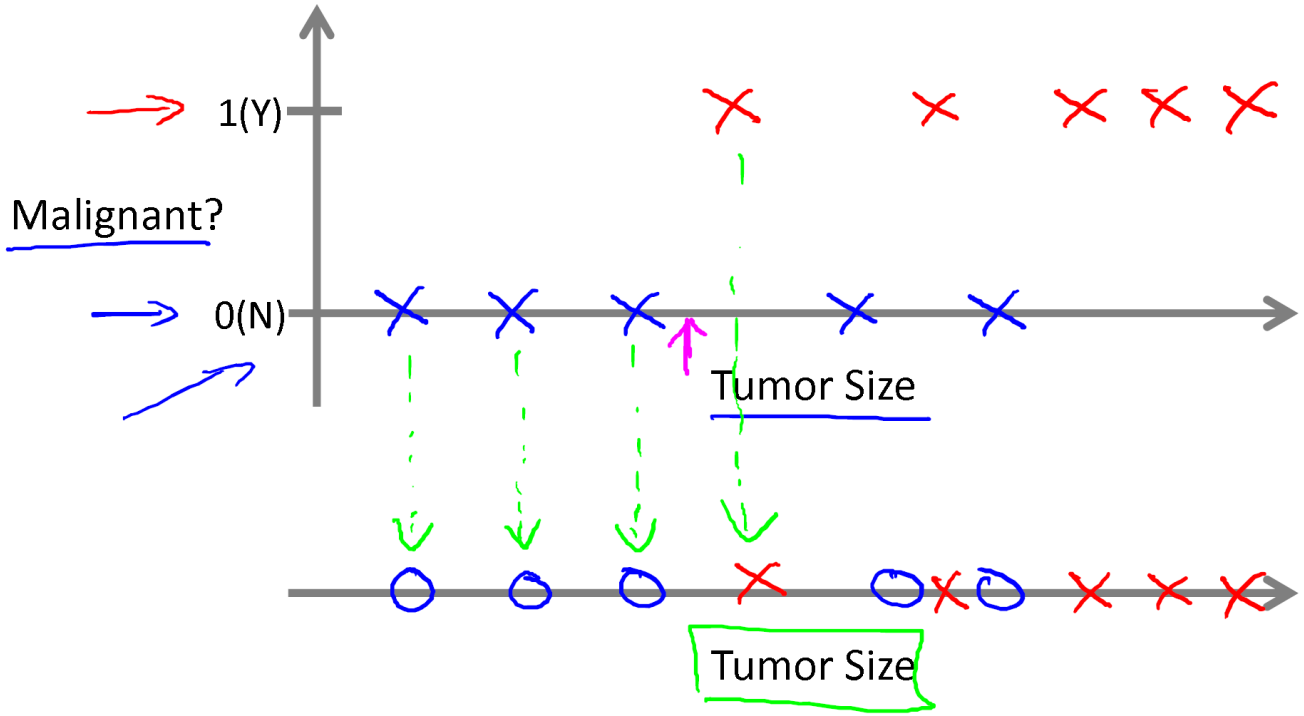
Supervised Learning and Regression



Regression: Predict *continuous* valued output (price)

Supervised Learning for Classification

Breast cancer (malignant, benign)



Classification

Discrete valued output (0 or 1)

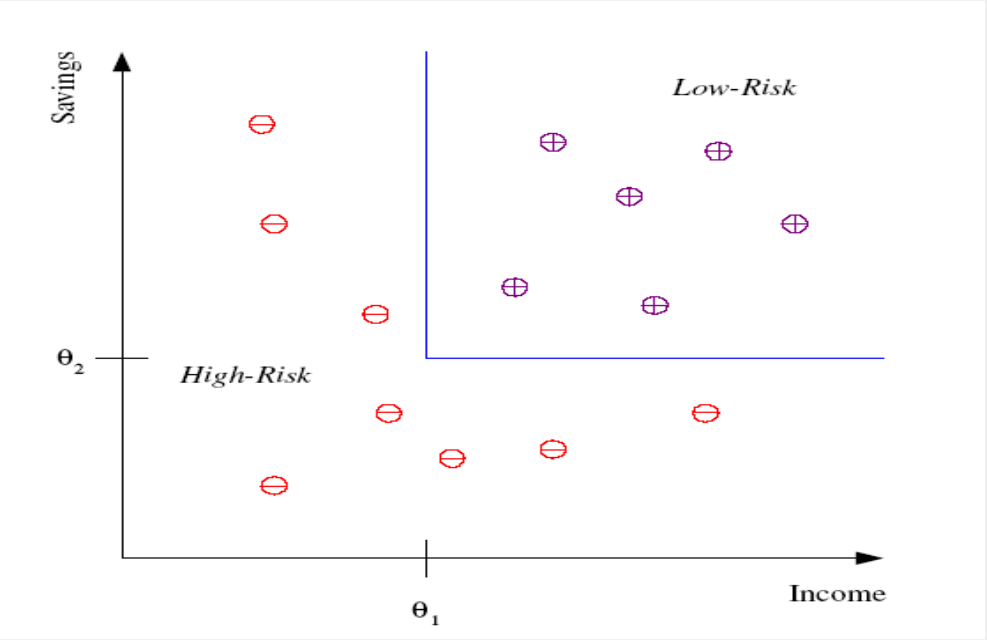
0, 1, 2, 3

benign

type 1 Cancer

Supervised Learning for Classification

- Example: Credit scoring
- Differentiating between low-risk and high-risk customers from their *income* and *savings*



Discriminant: IF *income* $> \theta_1$ AND *savings* $> \theta_2$
THEN low-risk ELSE high-risk

Model

#Checkpoint

You're running a company, and you want to develop learning algorithms to address each of two problems.

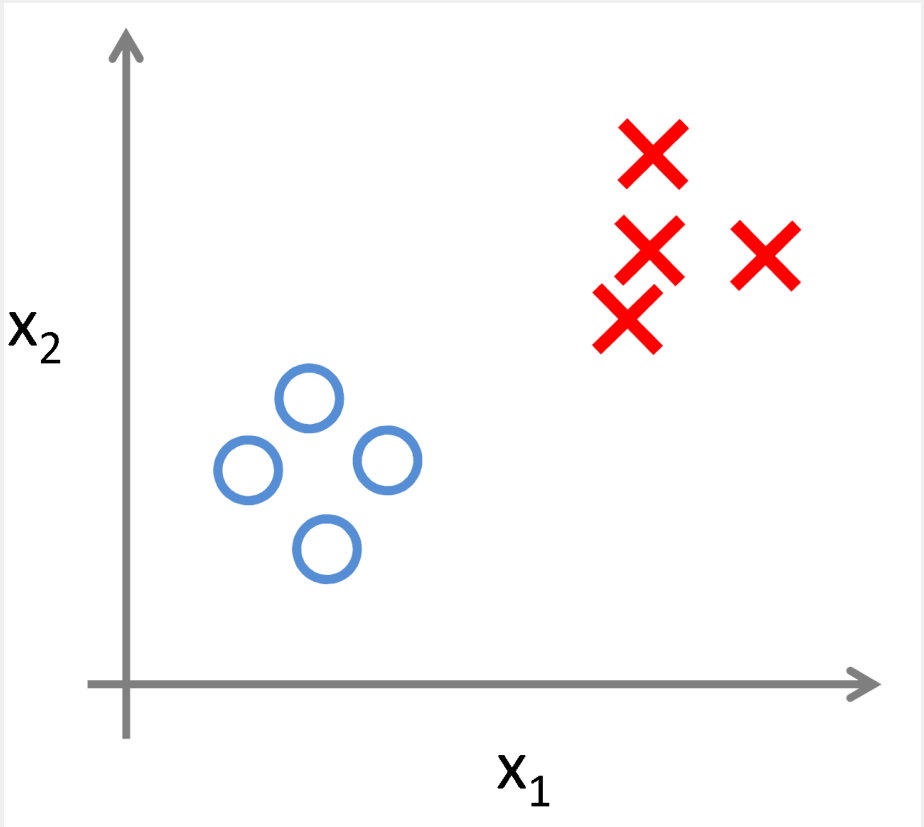
- ❑ Problem 1: You have a large inventory of identical items. You want to predict how many of these items will sell over the next 3 months.
- ❑ Problem 2: You'd like software to examine individual customer accounts, and for each account decide if it has been hacked/compromised.

Should you treat these as classification or as regression problems?

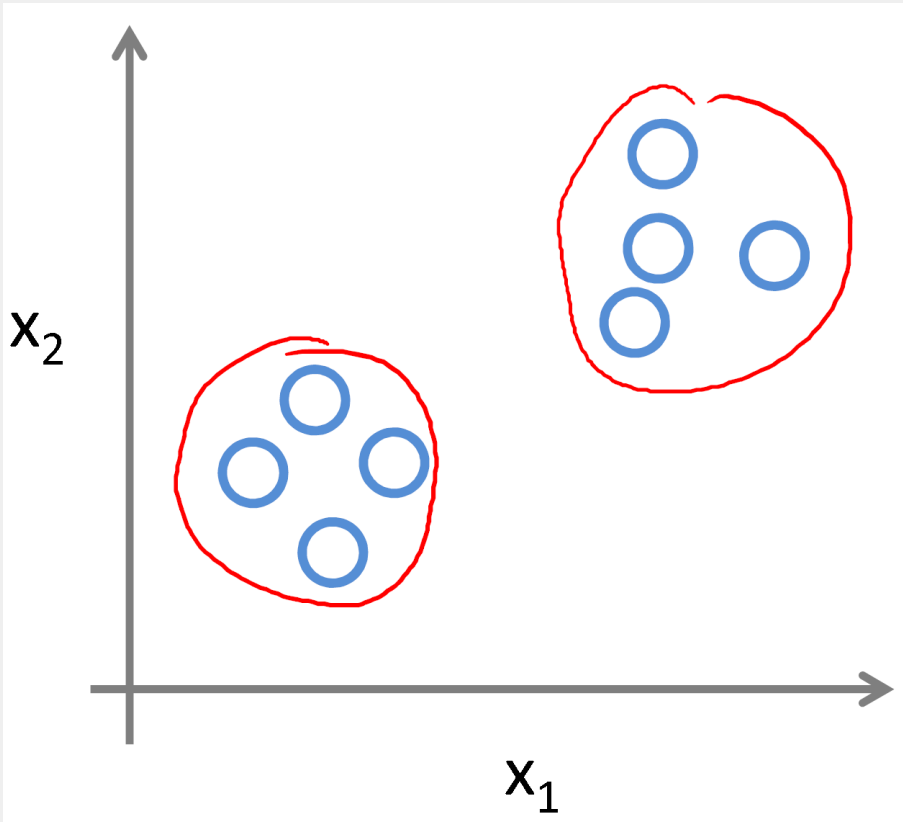
4. Introduction to Unsupervised Learning

Unsupervised?

Supervised Learning vs Unsupervised Learning

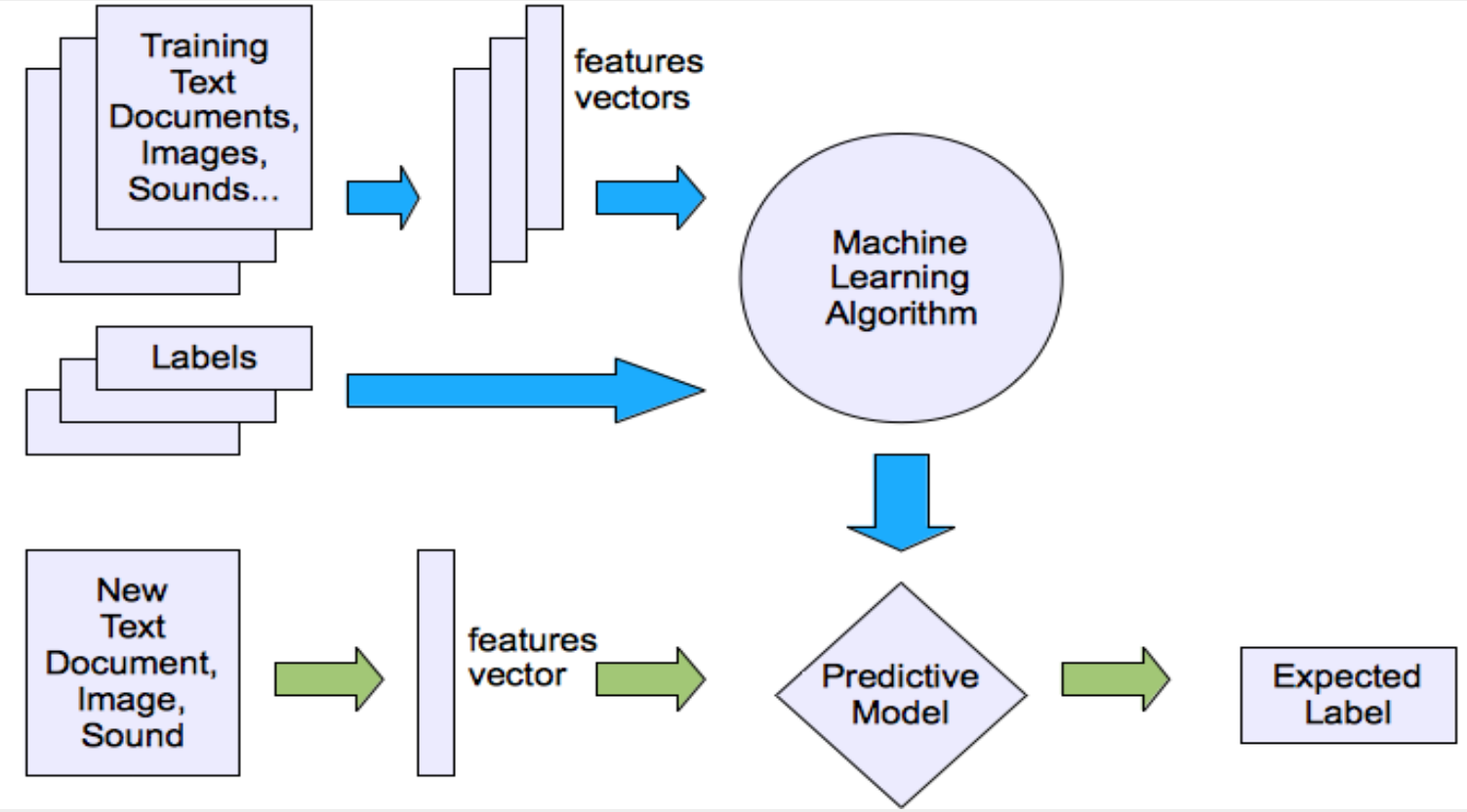


Supervised Learning



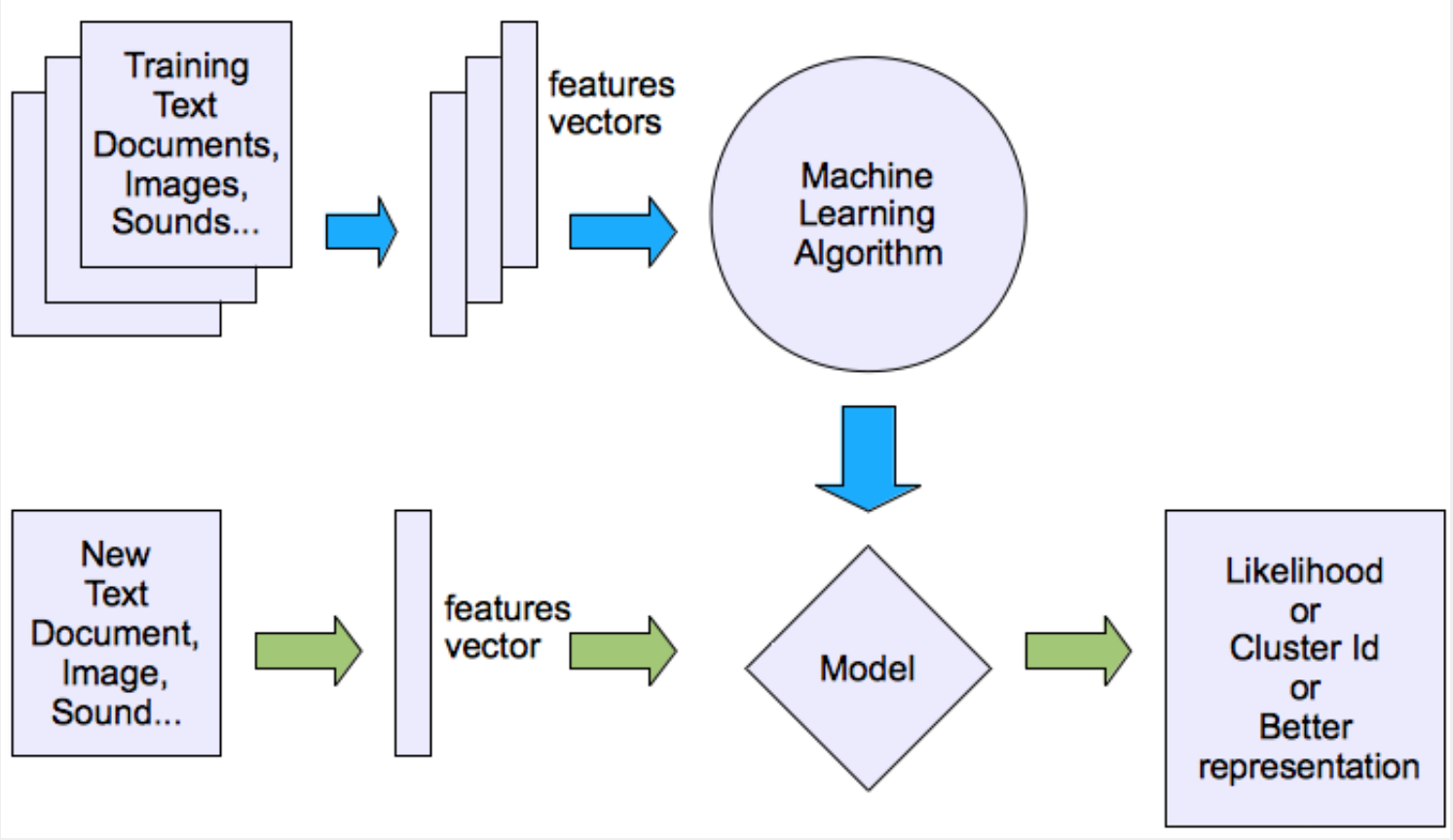
Unsupervised Learning

Supervised Learning



We seek low E-out or maximize probabilistic terms

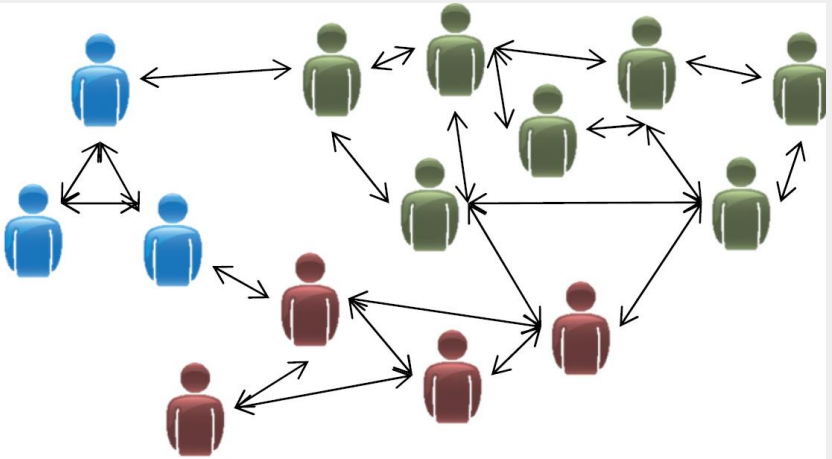
Unsupervised Learning



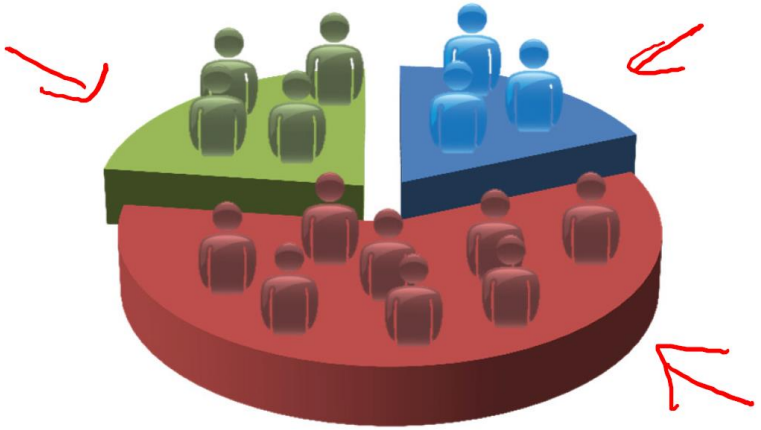
We seek minimum distance, MLE(maximum likelihood estimation) etc.

Sample Applications for Unsupervised Learning

Organize computing clusters



Social network analysis



Market segmentation

Astronomical data analysis

#Checkpoint

Of the following examples, which would you address using an unsupervised learning algorithm?

- ❑ Given a database of customer data, automatically discover market segments and group customers into different market segments.
- ❑ Given email labeled as spam/not spam, learn a spam filter.
- ❑ Given a set of news articles found on the web, group them into set of articles about the same story.
- ❑ Given a dataset of patients diagnosed as either having diabetes or not, learn to classify new patients as having diabetes or not.