LEARN. DO. EARN

ACADGILD

MACHINE LEARNING WITH R

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Brief Intro About ACADGILD: CEO – Vinod Dham, Father of Pentium

- ACADGILD is a technology education start-up which provides online courses in latest technologies like FrontEnd, FullStack, Big-Data, Android etc.

- Started by IIT/IIM alumni.
- Our aim is to provide job ready skills to millions of high school and college graduates, and working professionals.

Session 1: Introduction to Machine Learning

Agenda

- What is Machine Learning?
- Learning System Model
- Training and Testing
- Performance
- Algorithms
- Machine Learning Structure
- What Are We Seeking?
- Learning Techniques
- Applications
- Growth of Machine Learning
- Classification: Applications
- Face Recognition
- Prediction: Regression
- Regression Applications
- Supervised Learning: Uses
- Unsupervised Learning
- Reinforcement Learning

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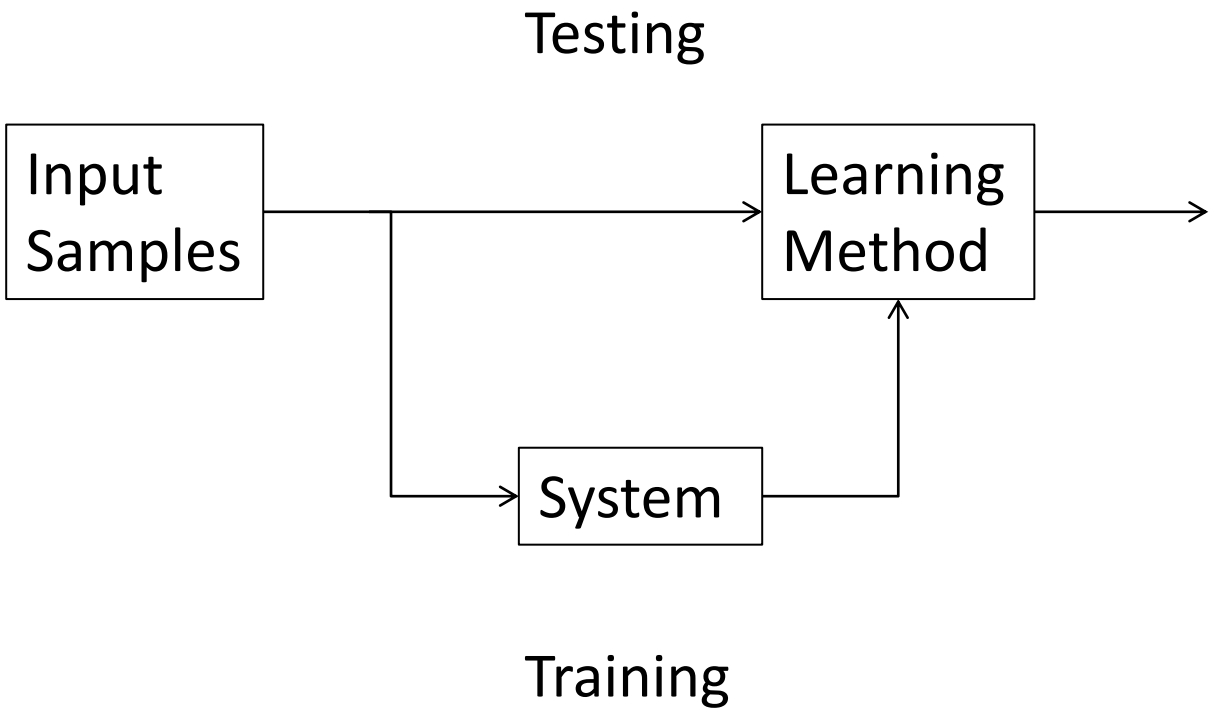
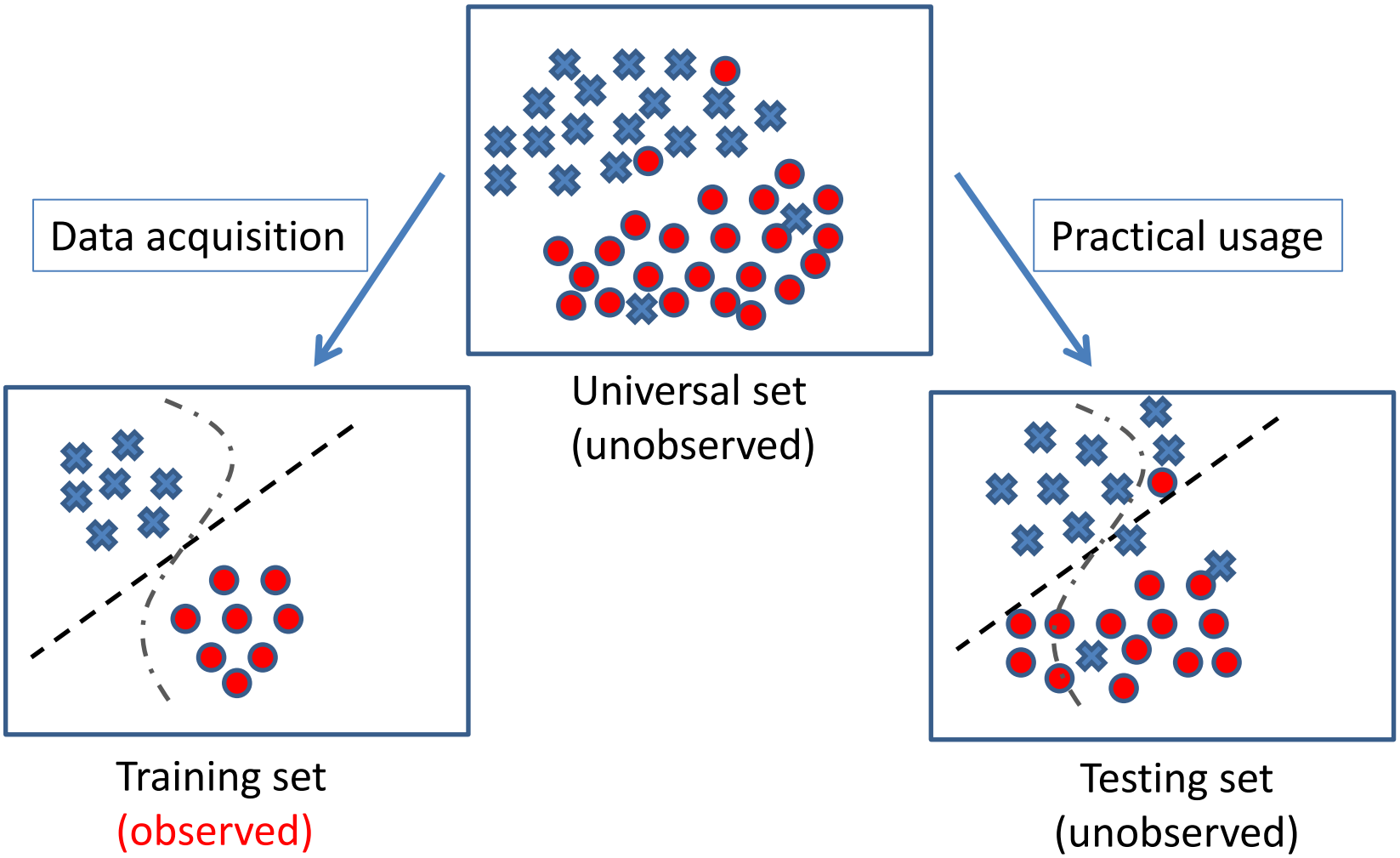
What is Machine Learning?

- A branch of artificial intelligence, concerned with the design and development of algorithms that allow computers to evolve behaviors based on empirical data.
- As intelligence requires knowledge, it is necessary for the computers to acquire knowledge.

Learning System Model

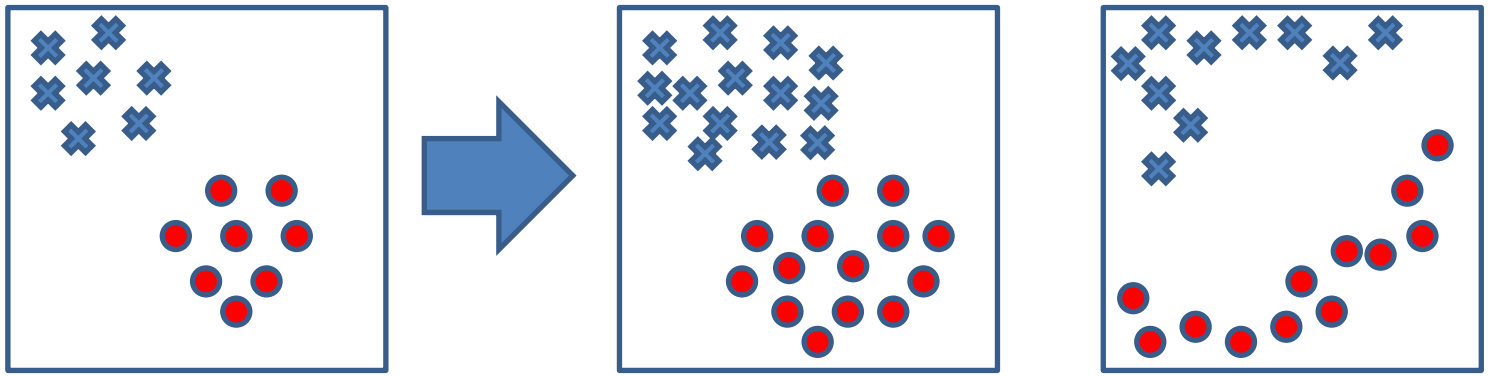


Training and Testing



Training and Testing (Contd.)

- Training is the process of making the system able to learn.
- No free lunch rule:
  - Training set and testing set come from the same distribution
  - Need to make some assumptions or bias



Performance

- There are several factors affecting the performance:
  - Types of training provided
  - The form and extent of any initial background knowledge
  - The type of feedback provided
  - The learning algorithms used

- Two important factors:
  - Modeling
  - Optimization

Algorithms

- The success of machine learning system also depends on the algorithms.
- The algorithms control the search to find and build the knowledge structures.
- The learning algorithms should extract useful information from training examples.

Algorithms (Contd.)

- Supervised learning
  - Prediction
  - Classification (discrete labels), Regression (real values)
- Unsupervised learning
  - Clustering
  - Probability distribution estimation
  - Finding association (in features)
  - Dimension reduction
- Semi-supervised learning
- Reinforcement learning
  - Decision making (robot, chess machine)

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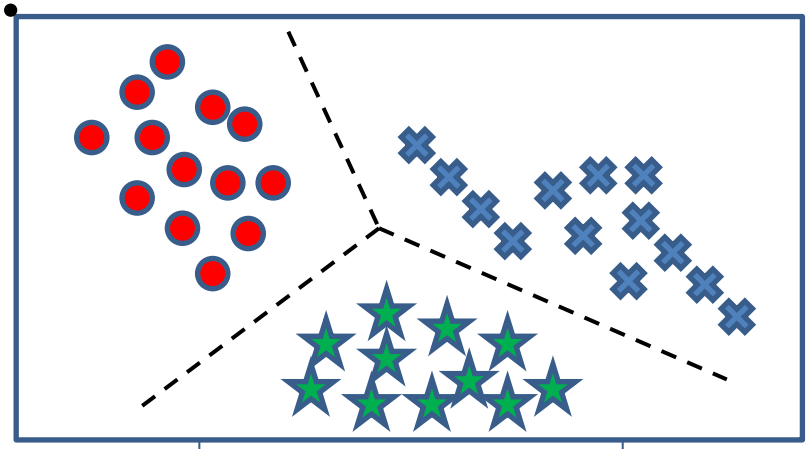
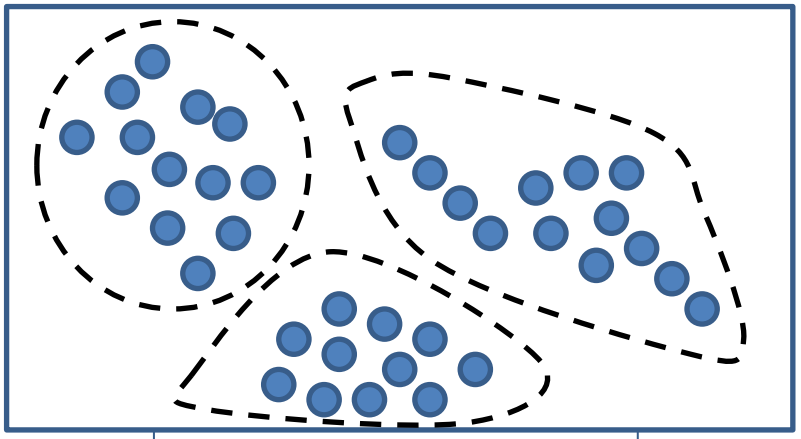
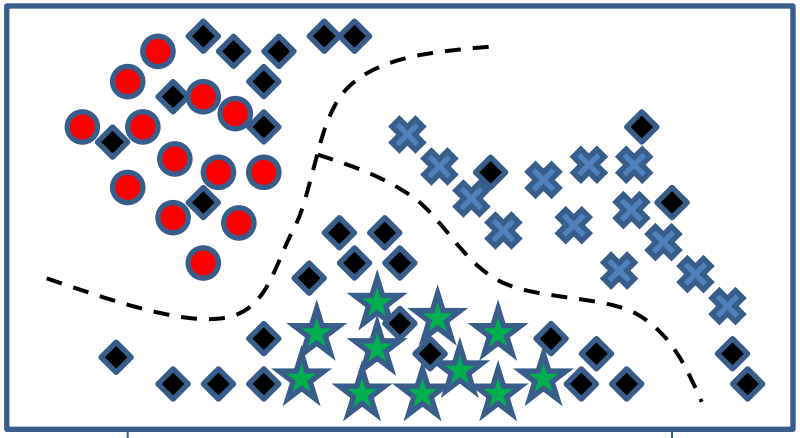
Algorithms (Contd.)



Supervised learning



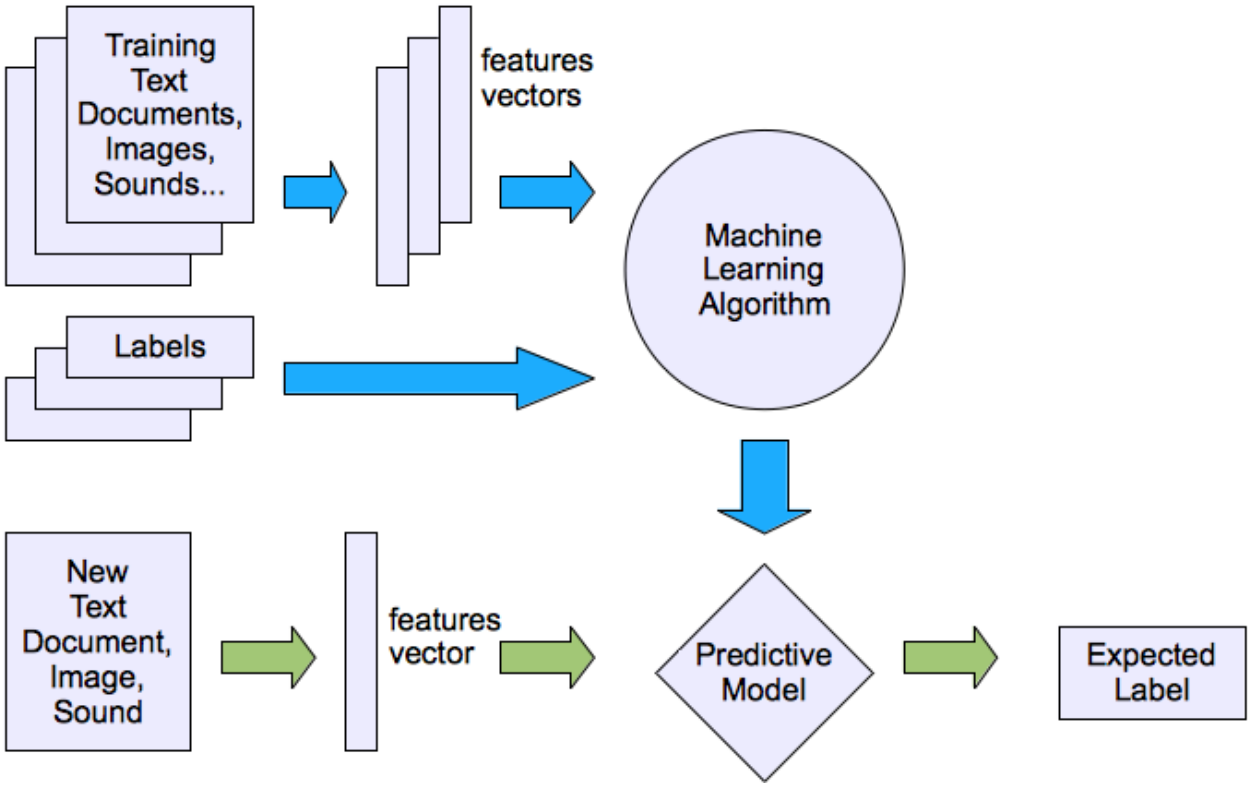
Unsupervised learning



Semi-supervised learning

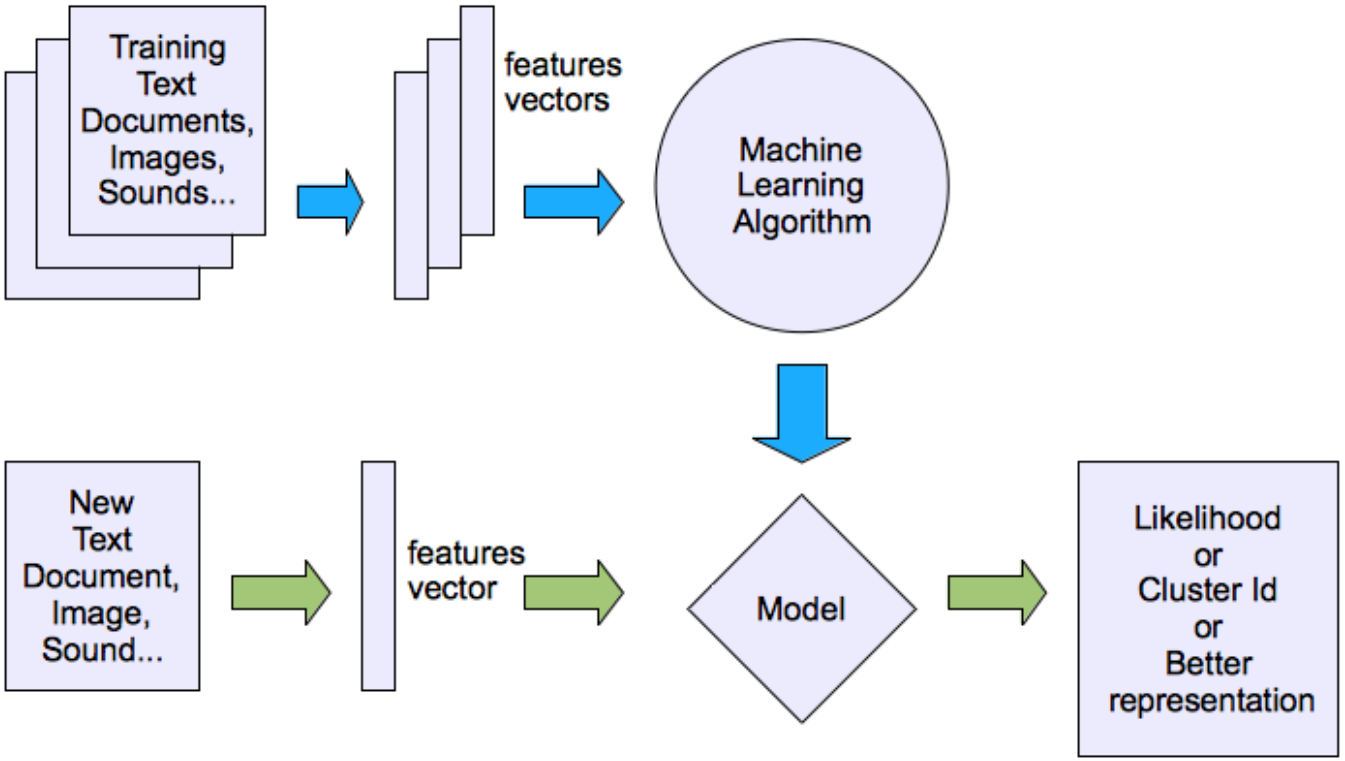
Machine Learning Structure

- Supervised learning

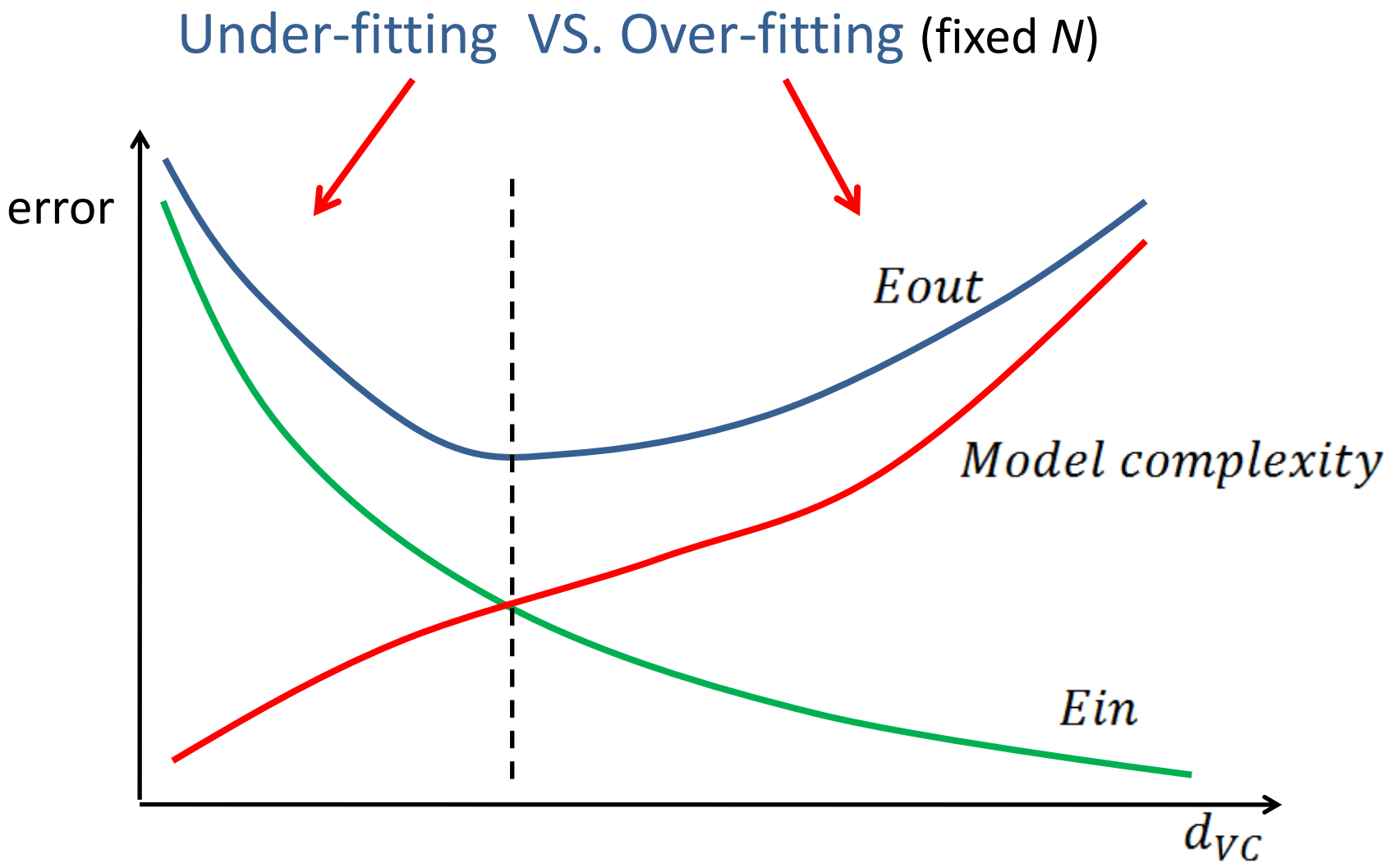


Machine Learning Structure (Contd.)

- Unsupervised learning



What Are We Seeking?



Learning Techniques

- Supervised learning categories and techniques
  - Linear classifier (numerical functions)
  - Parametric (Probabilistic functions)
    - Naïve Bayes, Gaussian discriminant analysis (GDA), Hidden Markov models (HMM), Probabilistic graphical models
  - Non-parametric (Instance-based functions)
    - K-nearest neighbors, Kernel regression, Kernel density estimation, Local regression
  - Non-metric (Symbolic functions)
    - Classification and regression tree (CART), decision tree
  - Aggregation
    - Bagging (bootstrap + aggregation), Adaboost, Random forest

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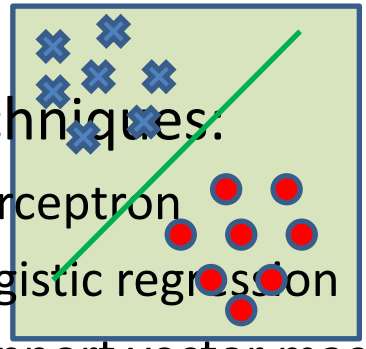
Learning techniques

- Linear classifier



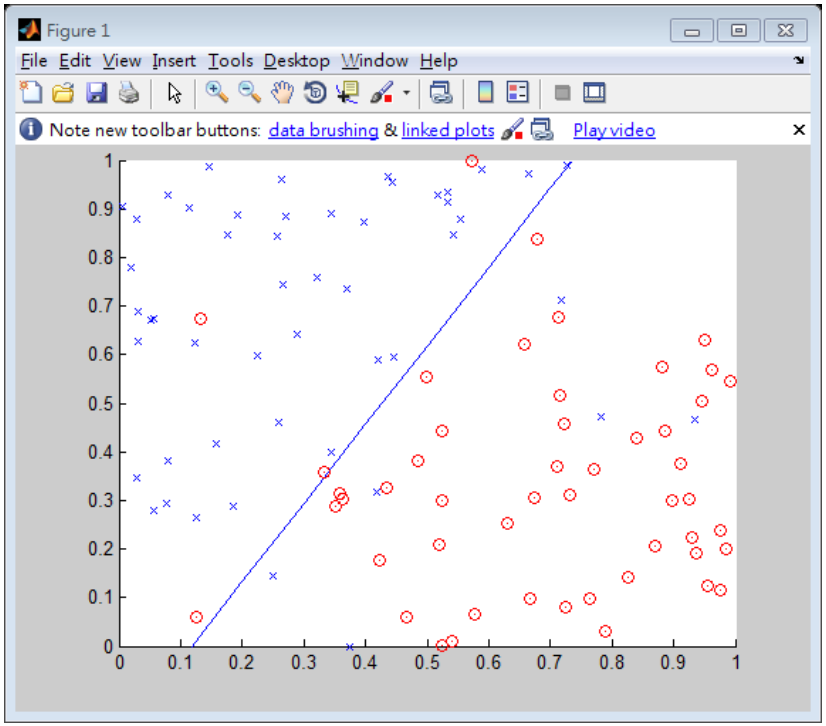
$$g(x_n) = sign(w^T x_n)$$

, where *w* is an *d*-dim vector (learned)

- Techniques:
  - Perceptron
  - Logistic regression
  - Support vector machine (SVM)
  - Ada-line
  - Multi-layer perceptron (MLP)

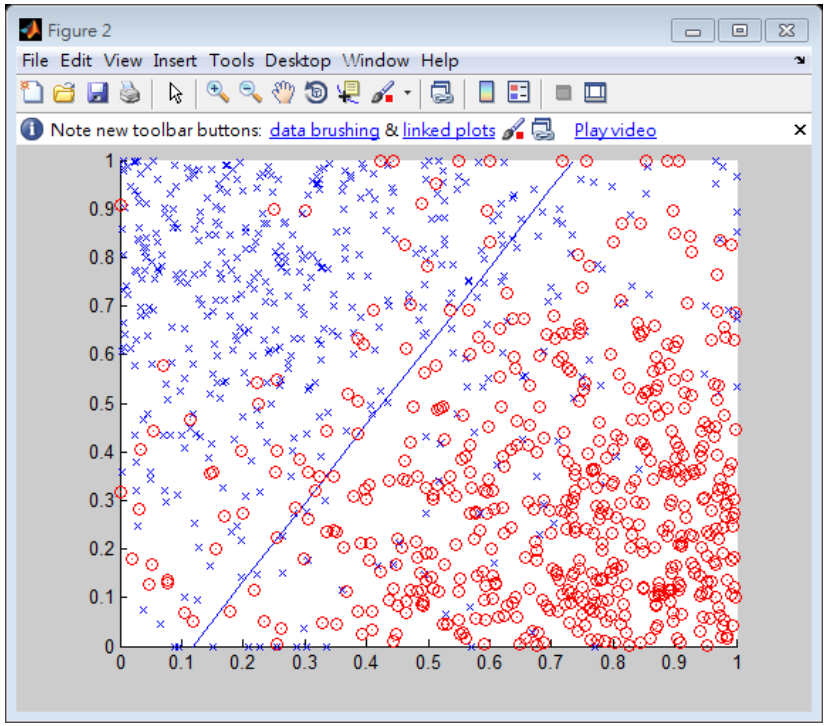
Learning Techniques (Contd.)

Using **perceptron learning algorithm**(PLA)



Training

Error rate: 0.10

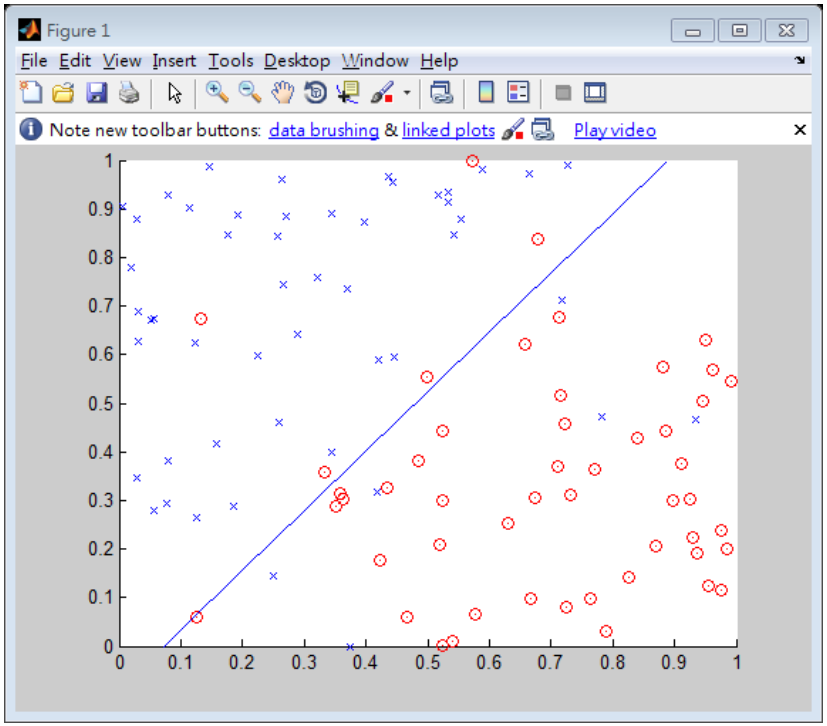


Testing

Error rate: 0.156

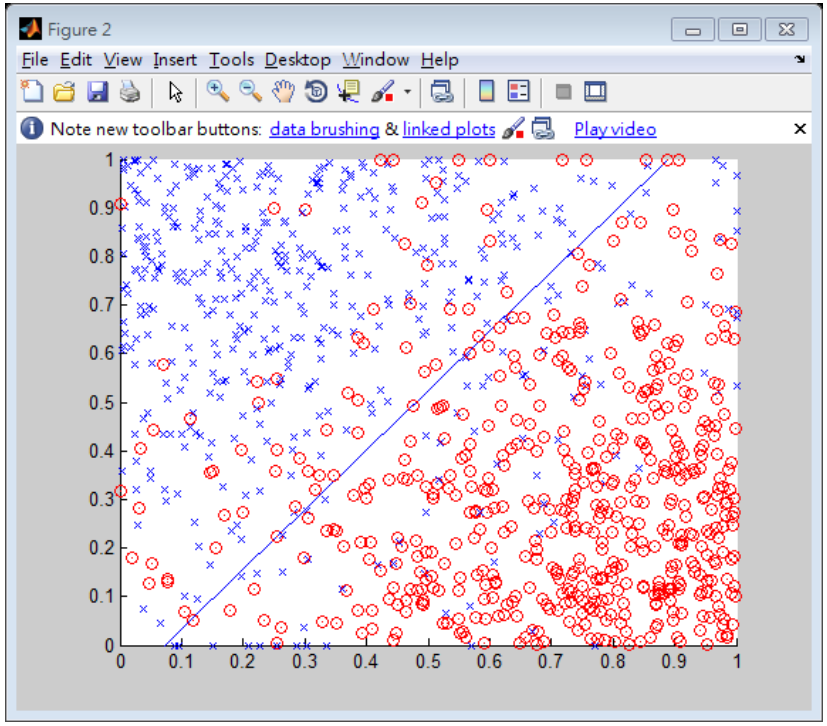
Learning Techniques (Contd.)

Using **logistic regression**



Training

Error rate: 0.11

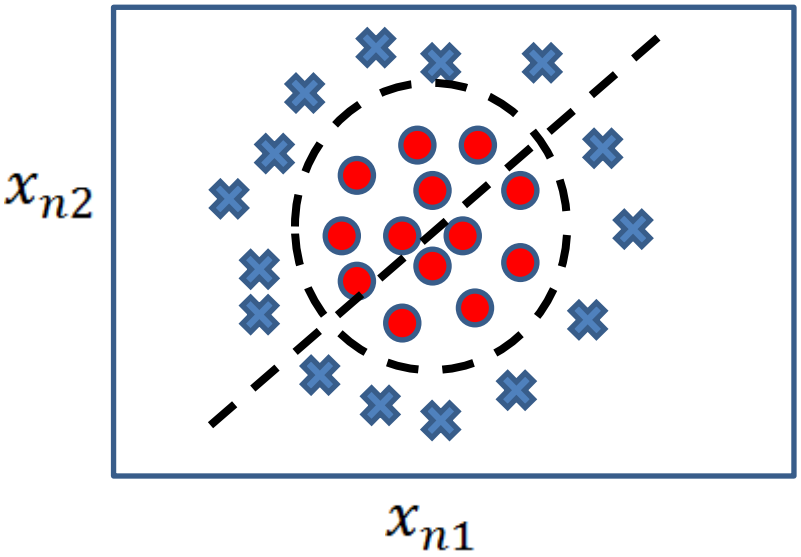


Testing

Error rate: 0.145

Learning Techniques (Contd.)

- Support vector machine (SVM):
  - Linear to nonlinear: Feature transform and kernel function
    - Non-linear case



$$x_n = [x_{n1}, x_{n2}]$$

$$x_n = [x_{n1}, x_{n2}, x_{n1} * x_{n2}, {x_{n1}}^2, {x_{n2}}^2]$$

$$g(x_n) = sign(w^T x_n)$$

Learning Techniques (Contd.)

- Unsupervised learning categories and techniques
  - Clustering
    - K-means clustering
    - Spectral clustering
  - Density Estimation
    - Gaussian mixture model (GMM)
    - Graphical models
  - Dimensionality reduction
    - Principal component analysis (PCA)
    - Factor analysis

Applications

- Face detection
- Object detection and recognition
- Image segmentation
- Multimedia event detection
- Economical and commercial usage

Growth of Machine Learning

- Machine learning is preferred approach to:
  - Speech recognition, Natural language processing
  - Computer vision
  - Medical outcomes analysis
  - Robot control
  - Computational biology
- This trend is accelerating
  - Improved machine learning algorithms
  - Improved data capture, networking, faster computers
  - Software too complex to write by hand
  - New sensors/IO devices
  - Demand for self-customization to user, environment

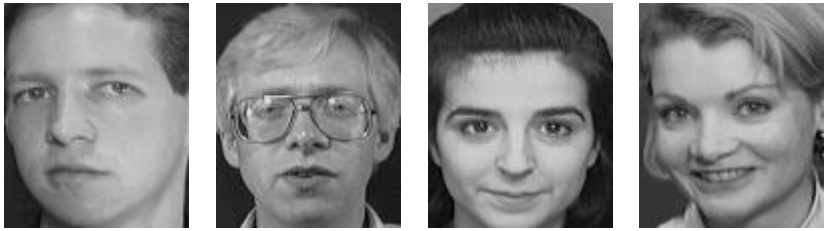
Classification: Applications

- Also known as Pattern recognition
- Face recognition: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- Character recognition: Different handwriting styles.
- Speech recognition: Temporal dependency.
  - Use of a dictionary or the syntax of the language.
  - Sensor fusion: Combine multiple modalities; eg, visual (lip image) and acoustic for speech
- Medical diagnosis: From symptoms to illnesses
- Web Advertising: Predict if a user clicks on an ad on the Internet.

Face Recognition

Training examples of a person

Test images



AT&T Laboratories, Cambridge UK
http://www.uk.research.att.com/facedatabase.html

Prediction: Regression

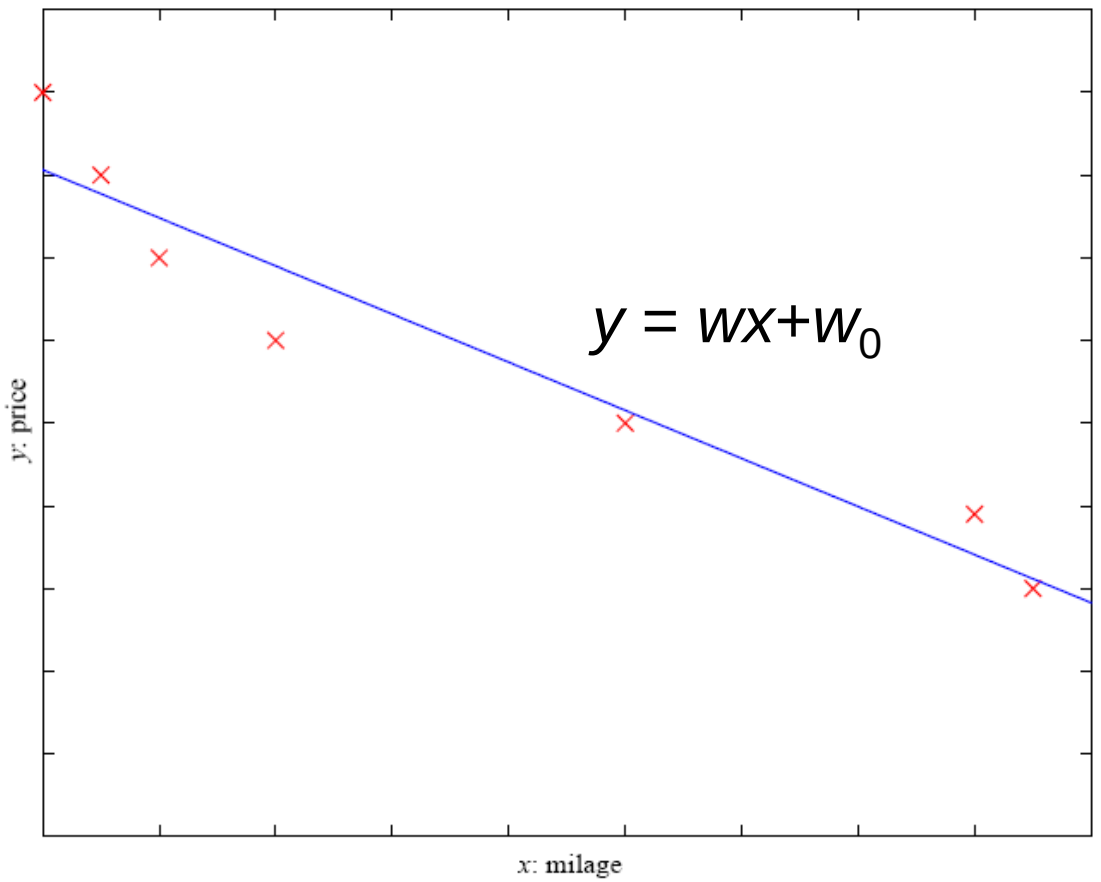
- Example: Price of a used car
- x : car attributes

  y : price

  $$y = g(x \mid \vartheta)$$

  $g(\ )$ model,

  ϑ parameters

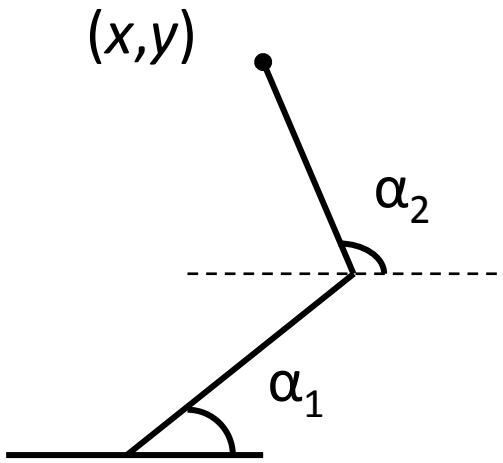


Regression Applications

- Navigating a car: Angle of the steering wheel (CMU NavLab)
- Kinematics of a robot arm

$$\alpha_1 = g_1(x,y)$$

$$\alpha_2 = g_2(x,y)$$



Supervised Learning: Uses

Example: decision trees tools that create rules

- Prediction of future cases: Use the rule to predict the output for future inputs
- Knowledge extraction: The rule is easy to understand
- Compression: The rule is simpler than the data it explains
- Outlier detection: Exceptions that are not covered by the rule, e.g., fraud

Unsupervised Learning

- Learning “what normally happens”
- No output
- Clustering: Grouping similar instances
- Other applications: Summarization, Association Analysis

Example applications

- Customer segmentation in CRM
- Image compression: Color quantization
- Bioinformatics: Learning motifs

Reinforcement Learning

Topics

- Policies: what actions should an agent take in a particular situation
- Utility estimation: how good is a state (used by policy)
- No supervised output but delayed reward
- Credit assignment problem (what was responsible for the outcome)

Applications

- Game playing
- Robot in a maze
- Multiple agents, partial observability, ...

Next Class: K Nearest Neighbors

Sl. No.	Agenda Topics
1.	Instance Based Classifiers
2.	Nearest Neighbor Classifiers
3.	Definition of Nearest Neighbor
4.	1 Nearest-Neighbor
5.	Nearest Neighbor Classification
6.	Lazy vs. Eager Learning
7.	Lazy Learner: Instance-Based Methods
8.	Nearest Neighbor Search
9.	Non-Numeric Data
10.	Dealing With Non-numeric Data
11.	Preprocessing Your Dataset

Sl. No.	Agenda Topics
12.	K-NN Variations
13.	How To Determine The Good Value For K?
14.	Other Distance Measures
15.	K-NN Time Complexity
16.	Curse of Dimensionality
17.	When to Consider Nearest Neighbors
18.	Proximity Graphs
19.	Nearest Neighbour Issues

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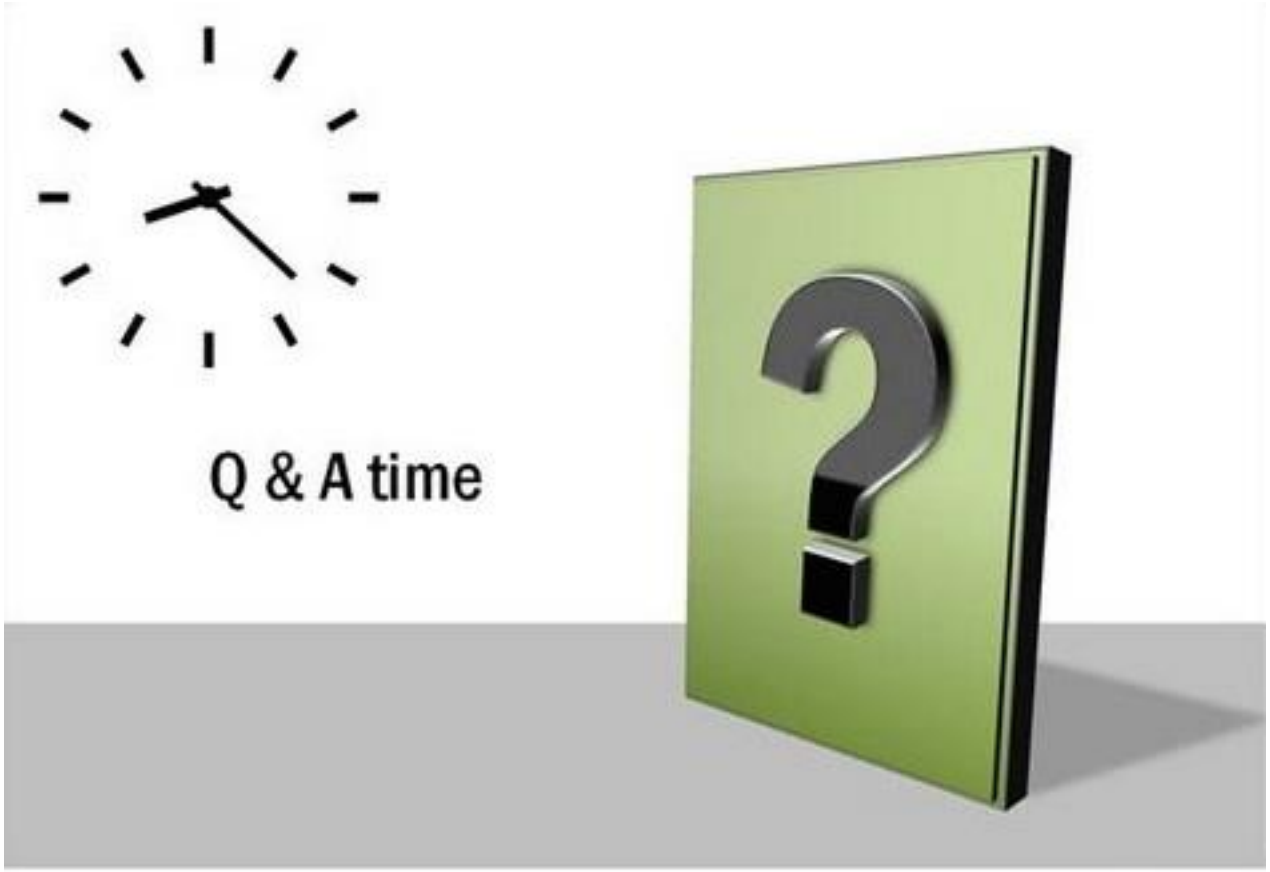
Q & A time

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