Machine Learning

Introduction

- To solve a problem on a computer, we need an algorithm.
- Algorithm = seq. of steps to get a desired output from the given input.
- E.g. Sorting numbers. Input=? Output=?
- Here we have the knowledge of what to do.
- Interested in finding the most efficient one – least no. of instr. or less space or both

Why Learn?

- Another e.g. differentiate spam emails from legitimate emails.
- Here we don’t have the knowledge of what needs to be done.
- So, we have to use data to make up for the lack of knowledge.
- We can learn from 1000’s of examples.

What is Machine Learning?

- In other words, we would like the computer(a machine) to extract algorithm automatically from the data(examples). This is nothing but learning.
- Machine learning is programming computers to optimize a performance criterion using example data or past experience.

When is Learning required?

- Learning is used when:
  - Human expertise does not exist (navigating on Mars),
  - Humans are unable to explain their expertise (speech recognition)
  - Solution changes in time (routing on a computer network)
  - Solution needs to be adapted to particular cases (user biometrics)

Data Mining

- Example in retail: Customer transactions to consumer behavior.
- Certain patterns do exist.
- So the goal is to build a model that is a good and useful approximation to the sample data.
- Data Mining : Application of machine learning methods to huge databases(for e.g. data warehouse).
- How did it get the name - Analogy

Data Mining – Application Areas

- Retail: Customer relationship management (CRM)
- Finance: Credit scoring, fraud detection
- Manufacturing: Control, robotics
- Medicine: Medical diagnosis
- Telecommunications: Spam filters, intrusion detection
- Bioinformatics: Motifs, alignment
- Web mining: Search engines

Roles

- Machine = a model up to some parameters
- Learning = execution of a computer program to optimize the parameters of the model using training data or past experience.
- Role of Statistics: Inference from a sample
- Role of Computer science: Efficient algorithms to
  - Solve the optimization problem
  - Representing and evaluating the model for inference

Types of learning

- Supervised Learning
  - Classification
  - Regression
- Unsupervised Learning
- Reinforcement Learning

Supervised Learning

- x : Input , y : Output
- The task is to learn the mapping

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

where,

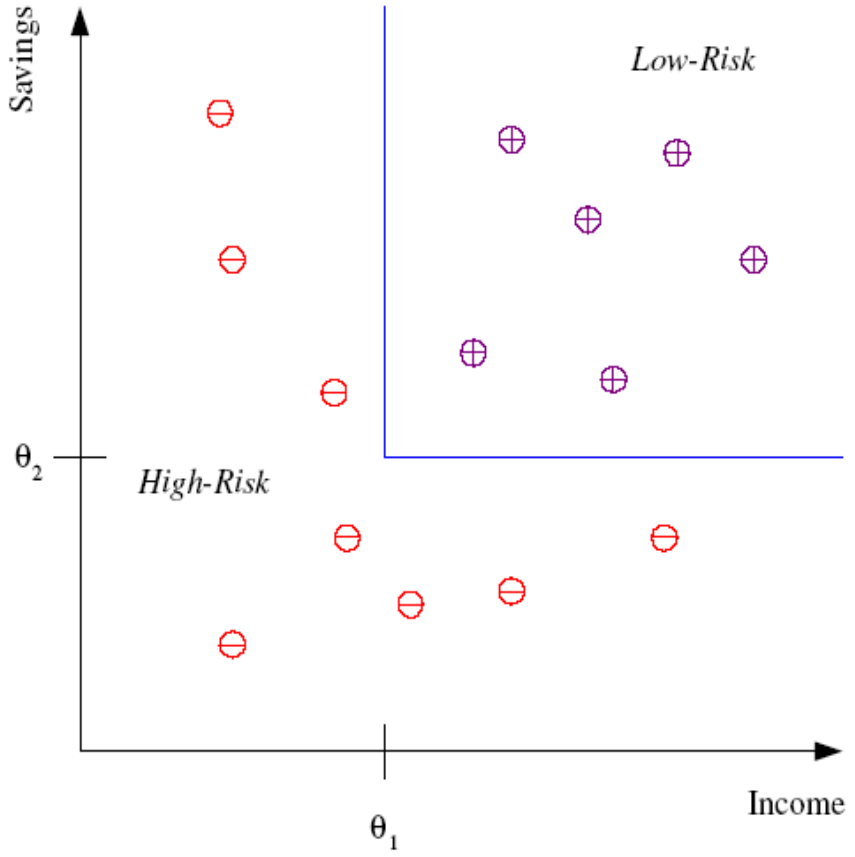
$g(\ ) =$ model,

$\theta =$ parameters

Machine Learning program optimizes these parameters θ such that the approximation error is minimized.

Classification

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



Discriminant: IF *income* > θ_1 AND *savings* > θ_2
THEN low-risk ELSE high-risk

Classification : Applications

- Pattern recognition
- Face recognition: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- Character recognition: Different handwriting styles.
- Speech recognition: Temporal dependency.
- Medical diagnosis: From symptoms to illnesses
- Biometrics: Recognition/authentication using physical and/or behavioral characteristics: Face, iris, signature, etc

Regression

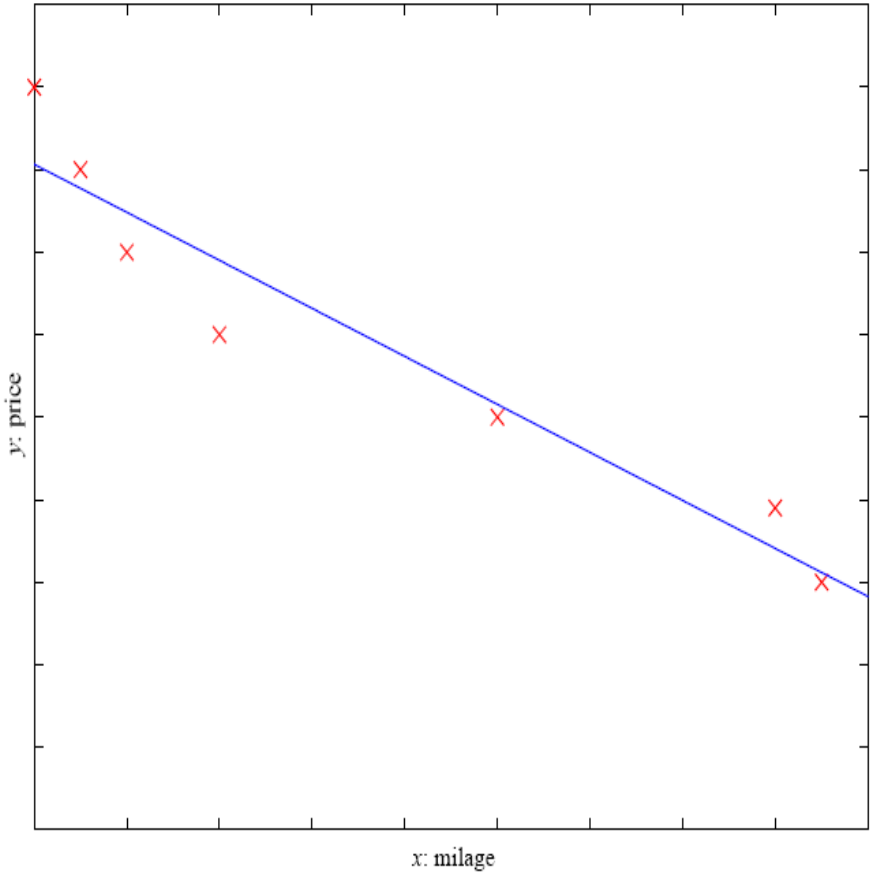
- Example: Price of a used car
- x : car attributes

  y : price

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

  $g(\ )$ model,

  θ parameters



Supervised Learning

- Classification:
  - y : Class code
  - g ( ) : Discriminant function separating instances of the classes.
- Regression:
  - y : Number
  - g ( ) : Regression function.

Unsupervised Learning

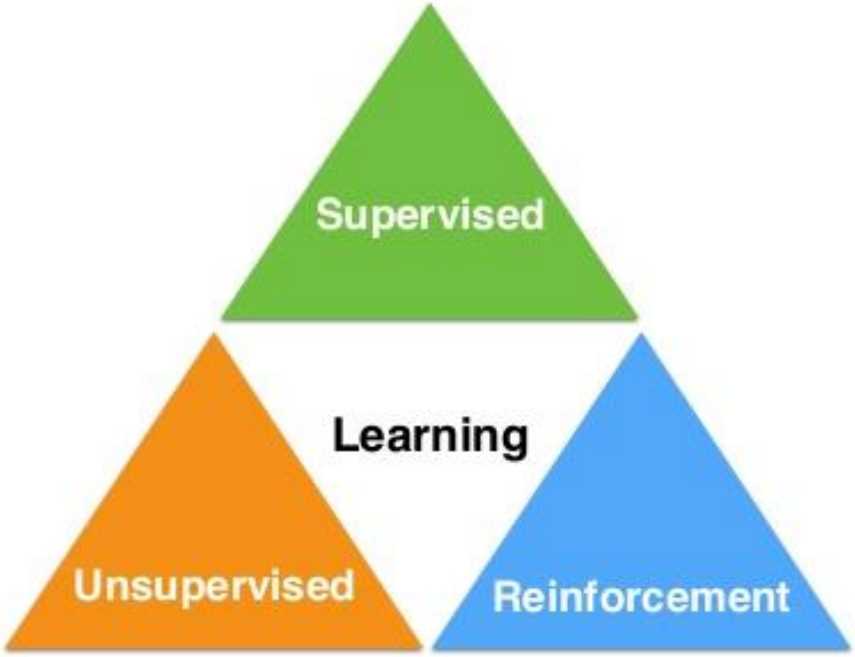
- Learning “what normally happens”
- No supervisor and no output. Only input
- Aim : To find regularities in the input.
- Clustering: Grouping similar instances
- Example applications
  - Customer segmentation in CRM
  - Image compression: Color quantization
  - Bioinformatics: Learning motifs

Reinforcement learning

- Learning a policy: A sequence of outputs
- No supervised output but delayed reward
- Credit assignment problem
- Game playing
- Robot in a maze
- Multiple agents, partial observability

Machine Learning Triangle

- Labeled data
- Direct feedback
- Predict outcome/future



- No labels
- No feedback
- "Find hidden structure"

- Decision process
- Reward system
- Learn series of actions

Machine Learning Use Cases

	Supervised Learning	Unsupervised Learning	Reinforcement Learning
Banking	**Predict credit worthiness of credit card holders**: Build a machine learning model to look for delinquency attributes by providing it with data on delinquent and non-delinquent customers	**Segment customers by behavioral characteristics**: Survey prospects and customers to develop multiple segments using clustering	**Create a 'next best offer' model for the call center group**: Build a predictive model that learns over time as users accept or reject offers made by the sales staff
Healthcare	**Predict patient readmission rates**: Build a regression model by providing data on the patients' treatment regime and readmissions to show variables that best correlate with readmissions	**Categorize MRI data by normal or abnormal images**: Use deep learning techniques to build a model that learns different features of images to recognize different patterns	**Allocate scarce medical resources to handle different types of ER cases**: Build a Markov Decision Process that learns treatment strategies for each type of ER case
Retail	**Analyze products customers buy together**: Build a supervised learning model to identify frequent item sets and association rules from transactional data	**Recommend products to customers based on past purchases**: Build a collaborative filtering model based on past purchases by "customers like them"	**Reduce excess stock with dynamic pricing**: Build a dynamic pricing model that adjusts the price based on customer response to offers

Data Mining

vs

Machine Learning

vs

Deep Learning

Data Mining

Data mining can be considered a superset of many different methods to extract insights from data. It might involve traditional statistical methods and machine learning. Data mining applies methods from many different areas to identify previously unknown patterns from data. This can include statistical algorithms, machine learning, text analytics, time series analysis and other areas of analytics. Data mining also includes the study and practice of data storage and data manipulation.

Machine Learning

The main difference with machine learning is that just like statistical models, the goal is to understand the structure of the data - fit theoretical distributions to the data that are well understood. So, with statistical models there is a theory behind the model that is mathematically proven, but this requires that data meets certain strong assumptions too. Machine learning has developed based on the ability to use computers to probe the data for structure, even if we do not have a theory of what that structure looks like. The test for a machine learning model is a validation error on new data, not a theoretical test that proves a null hypothesis. Because machine learning often uses an iterative approach to learn from data, the learning can be easily automated. Passes are run through the data until a robust pattern is found.

Deep Learning

Deep Learning combines advances in computing power and special types of neural networks to learn complicated patterns in large amounts of data. Deep learning techniques are currently state of the art for identifying objects in images and words in sounds. Researchers are now looking to apply these successes in pattern recognition to more complex tasks such as automatic language translation, medical diagnoses and numerous other important social and business problems.

Questions?