

CS6611

Introduction to Machine Learning

What is learning

“Learning denotes changes in a system that ... enable a system to do the same task ... more efficiently the next time.” - Herbert Simon

What is Machine Learning

- Machine learning (ML) is the study of computer algorithms that improve automatically through experience
- The ML algorithms build a model based on sample data known as “training data” for decision making tasks such as prediction/classification without being explicitly programmed to do so
- Optimize the performance criterion using training data or past experience
- It is subset of Artificial Intelligence

Why is Machine Learning

- ML exploits the knowledge for decision making tasks based on the philosophy that knowledge provides intelligence
- There are certain decision making tasks where huge data may be used for decision making (classification or prediction)
- Abundant data is available related to the different domain
- Particularly suited for tasks that involve image, speech signals or large text processing
- For example: Healthcare data from Electronic Health Records and from various research organizations, whether data, buying pattern data, stock market price data etc.

Learning cases

- When human expertise does not exist. For example navigating on Mars
- When solution changes in time. For example routing on a computer network
- Human expertise is limited. For example computational power

Why ML trend is growing

- New sensors / IO devices
- Improved machine learning algorithms
- Improved data capture, networking, faster computers
- Knowledge in any domain is limited. This is the prime reason of failure of expert systems.

Applications

- Speech recognition
- Natural language processing
- Computer vision
- Healthcare
- Robot control
- Computational biology

Types of Learning

- Association Analysis
- Supervised Learning
 - Classification
 - Regression/Prediction
- Unsupervised Learning
- Reinforcement Learning

Learning associations

- Basket analysis:

$P(Y | X)$ probability that somebody who buys X also buys Y where X and Y are products/services.

Example: $P(\text{Toothbrush} | \text{Toothpaste}) = 0.7$

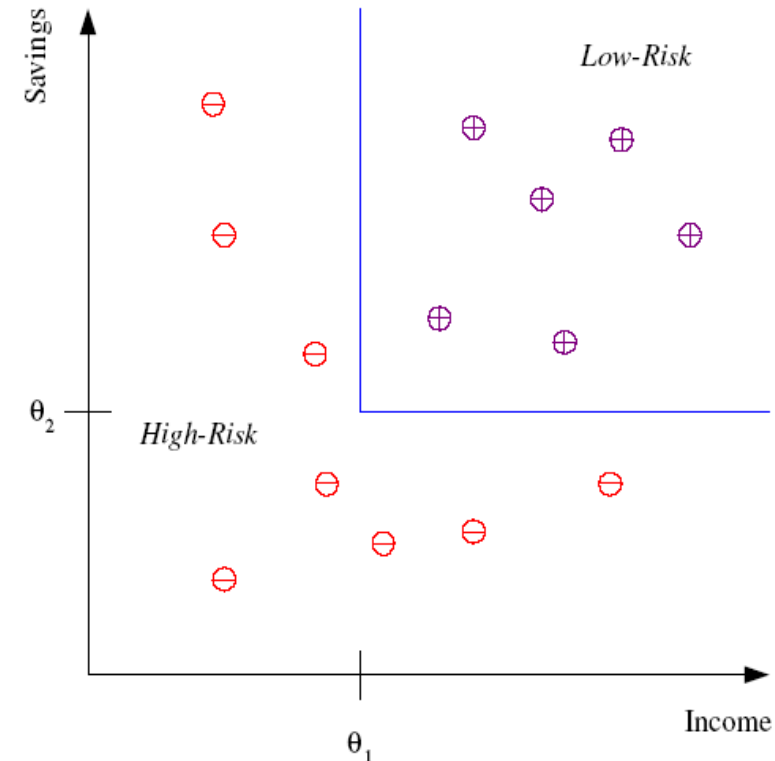
Market- Basket transactions

Transaction ID	Items
1	Milk, Bread
2	Bread, Butter, Eggs, Coke
3	Bread, Milk, Butter, Coke
4	Bread, Eggs, Coke
5	Bread, Butter, Coke

Classification

- Classifying 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**



Prediction

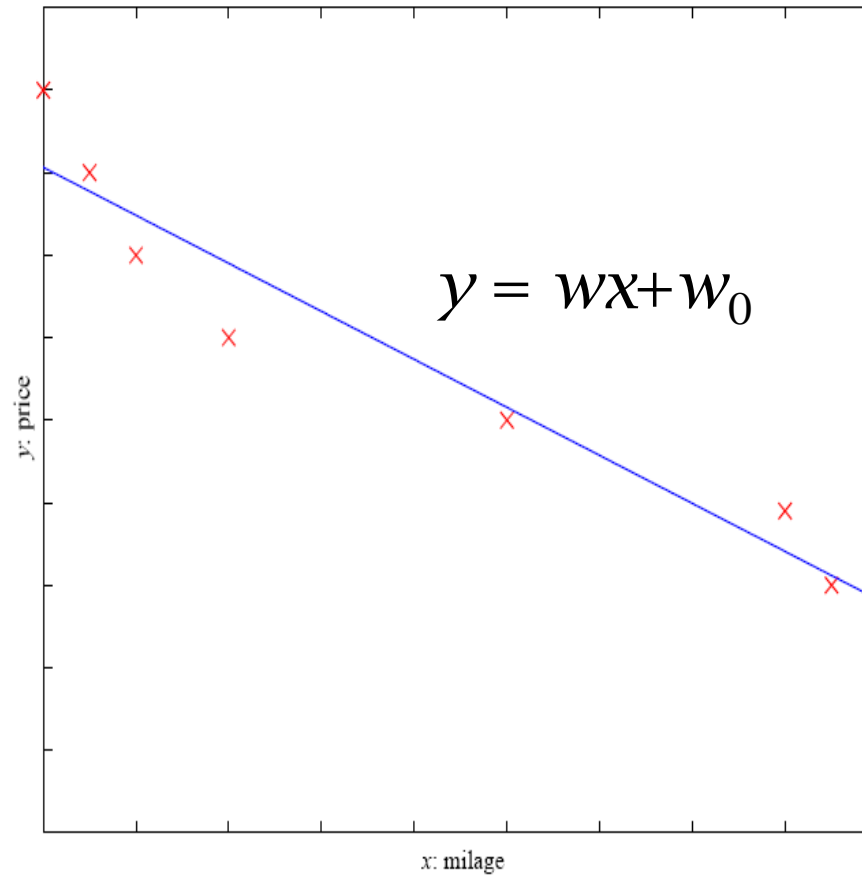
- Price of a used car
- x : car attributes

y : price

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

$g()$ model,

θ parameters



Unsupervised Learning

- It is a type of ML algorithm that draws inference from the input datasets without labels or target values
- The most common method of unsupervised learning is clustering that groups the data that has not been labelled
- Cluster analysis identifies the similarities in the data and accordingly forms different groups
- The idea is to keep the more similar datapoints in the same group
- Applications of clustering:
 1. Medical diagnosis - identifying cancerous data
 2. Wireless Sensor Network – identifying cluster heads
- In coming lectures we will study clustering techniques in detail

Reinforcement learning

- In this type of learning, an agent learns to behave in an environment by performing actions and seeing the results
- The agent uses hit and trial method to reach to a decision what works better
- The main components in reinforcement learning is the agent and the environment
- The environment is the setting on which the agent is acting on
- The agent either gets the reward or the punishment for the performed action
- The idea is to take appropriate actions for maximizing the rewards and minimizing the punishments

Reinforcement learning

The basic process of reinforcement learning:

1. Environment sends a state to the agent and the agent take some action on that state
 2. Then the agent get the next state and the reward for the action
 3. This process continues until the agent gets the terminal state when he/she completes all the tasks and gets the final reward
- An analogy of the above process is counter strike game

Reinforcement learning

Some definitions:

1. Agent: The RL algorithm that learns from trial and error
2. Environment: The world through the agent moves
3. Action(s): All the possible steps that the agent can take
4. State(s): Current condition returned by the environment