MACHINE LEARNING ALGORITHMS

(BAIL203)

Dr. Gopal Sakarkar
Department of AI, GHRCE, Nagpur

YouTube Channel on Machine Learning Algorithms
https://tinyurl.com/GopalMachineLearningAlgorithms

ABOUT COURSE

Course Objectives :-

1. To introduce the basic machine learning algorithms.
2. To understand nature of the problem and apply machine learning algorithm

Course Outcomes :-

1. To understand complexity of Machine Learning algorithms and their limitations;
2. To understand modern notions in machine learning and computing;
3. Be capable of confidently applying common Machine Learning algorithms in practice and implementing their own;
4. Be capable of performing experiments in Machine Learning using real-world data.
5. Implementing different learning models

ABOUT COURSE

- Machine learning is concerned with the question of how to make computers learn from experience.
- The ability to learn is not only central to most aspects of intelligent behavior, but machine learning techniques have become key components of many software systems.
- For examples, machine learning techniques are used to create spam filters, to analyze customer purchase data, or to detect fraud in credit card transactions.
- The field of *Machine Learning,* which addresses the challenge of producing *machines* that can learn, has become an extremely active, and exciting area, with an ever expanding inventory of practical (and profitable) results, many enabled by recent advances in the underlying theory.
- This course will introduce the fundamental set of techniques and algorithms that constitute machine learning

Marks Distribution

<table>
<tr><td colspan="10">Course Title: Machine Learning Algorithms</td></tr>
<tr><td rowspan="2">Semester</td><td rowspan="2">IV</td><td colspan="4" rowspan="2">Teaching Scheme</td><td colspan="5">Evaluation Scheme</td></tr>
<tr><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Term</td><td>EVEN</td><td>Th</td><td>Tu</td><td>Pr</td><td>Credits</td><td>TAE</td><td>CAE</td><td>ESE</td><td>INT</td><td>EXT</td></tr>
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<tr><td>Course Code</td><td>BAIL203/ BAIP203</td></tr>
<tr><td>Teaching Mode</td><td></td><td colspan="3" rowspan="2">4</td><td rowspan="2">Total</td><td colspan="3">50</td><td colspan="2">50</td></tr>
<tr><td>Duration of ESE</td><td></td><td colspan="5">100</td></tr>
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TAE and CAE planning

1. Assignment should be taken on weekly basis as per below

a. MCQ on basics and introduction of MLA (10 M)

b. Implementation of Regression Algorithms , Over fitting , Collaborative Recommendation (10 M)

c. Implementation of Logistics regression, SVM , Bayes Learning (10 M)

d. Implementation of PCA, Clustering. (10 M)

1. All above Assignments should be mapped with TAE1 and TAE2.
2. CAE examination should be breakup as 10 Marks on implantation/ numerical problem and 5 Mark on descriptive out of 15 Marks.
3. Syllabus for CAE 1 will be Unit 1 and 2 (11 to 13 Feb) and CAE-2 will be on Unit 3, 4 and 5 (22 to 24 Apr).

COURSE CONTENT

Introduction: Basic definitions, types of learning, hypothesis space and inductive bias, evaluation, cross-validation

Probability and Bayes learning, Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM

Clustering: k-means, adaptive hierarchical clustering, Gaussian mixture model

Linear regression, Decision trees, over fitting, Instance based learning, Feature reduction, Collaborative filtering based recommendation

Computational learning theory, PCA learning model, Sample complexity, VC Dimension, Ensemble learning

Test Books

Introduction to Machine Learning,
DAS GANU PRAKASHAN

Dr. Nilesh Shelke,
Dr. Narendra Chaudhari ,
Dr. Gopal Sakarkar

Python with Machine Learning,
S. Chand Prakashan.

Dr. A Krishna Mohan,
Dr. T Murali Mohan,
Karunakar

Introduction to machine learning —2nd ed.,
The MIT Press, Cambridge, Massachusetts, London, England.

Ethem Alpaydin

Dr. Nilesh Shelke is a senior faculty at Computer Science & Engineering Department of Priyadarshini Indira Gandhi College of Engineering, Nagpur. He has completed his MCA from Amravati University and M. Tech. in Computer Science & amp; Engineering from RTM Nagpur University. He is M.Phil in Computer Science and also acquire Ph.D. in Computer Science & Engg from S.G.B. Amravati University, Amravati. He is Microsoft Certified Solution Developer and has more than 20 years of experience of imparting IT Training which includes learners from different streams, faculties and Microsoft Certifications to corporate employees. He has contributed in framing a syllabus for B.E. CSE and IT board of RTMNU and YCMOU. He has published patents, copyrights and sellable technical articles in the renowned journals. He has successfully completed many certifications from IIT through NPTEL including Machine Learning, Deep Learning, Data Science, Databases etc. He is also mentoring several students in student's centric activities where many of his students had given outstanding performances including excellent placements, IIT Certifications, smart hackathon competition, paper publications etc.

Dr. Narendra Chaudhari, Presently the Head of Department of Computer Science & amp; Engineering and Dean Academics at G. H. Raisoni Institute of Engineering & Technology, Nagpur (An Autonomous Institute). He has completed his B.E. and M.Tech. in Computer Science & Engineering from RTM Nagpur University and acquire Ph.D. in Computer Science & Engg from S.G.B. Amravati university, Amravati. Dr. Chaudhari is having 23 years of teaching experience and contributed in framing a syllabus for B.E. CSE-CT and IT-CE board of RTMNU. He is passionate about creative and innovative teaching methods and penned a book "Work Book on Computational Skills" containing creative exercises. He has to his credit several publications in National and International journals and conferences and guided numerous UG and PG projects.

Dr. Gopal Sakarkar has completed his research degree in Computer Science and Engineering from S.G.B. Amravati University, Amravati. He has 12 years of teaching and research experience and now he is currently working in Department of Artificial Intelligence and Machine Learning at G H Raisoni College of Engineering, Nagpur. He has excellent array of research papers including 10 papers in International Journals (4 papers in Scopus), 11 papers in International Conferences (Springer and Elsevier) and 5 papers in National conferences, 1 patent filed and 2 copyrights in his bag. He was awarded as Best Teacher for session 2018-2019 at G H Raisoni College of Engineering(An Autonomous Institute), Nagpur.

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INTRODUCTION TO MACHINE LEARNING ● Dr. Nilesh Shelke, Dr. Narendra Chaudhary, Dr. Gopal Sakarkar ● Das Ganu Prakashan, Nagpur

DAS GANU PRAKASHAN
NAGPUR

INTRODUCTION TO MACHINE LEARNING

Dr. Nilesh Shelke
Dr. Narendra Chaudhary
Dr. Gopal Sakarkar

Course Content

Introduction

I

Machine Learning is a buzzword for the past few years

II

The reason for this might be the high amount of data production by applications

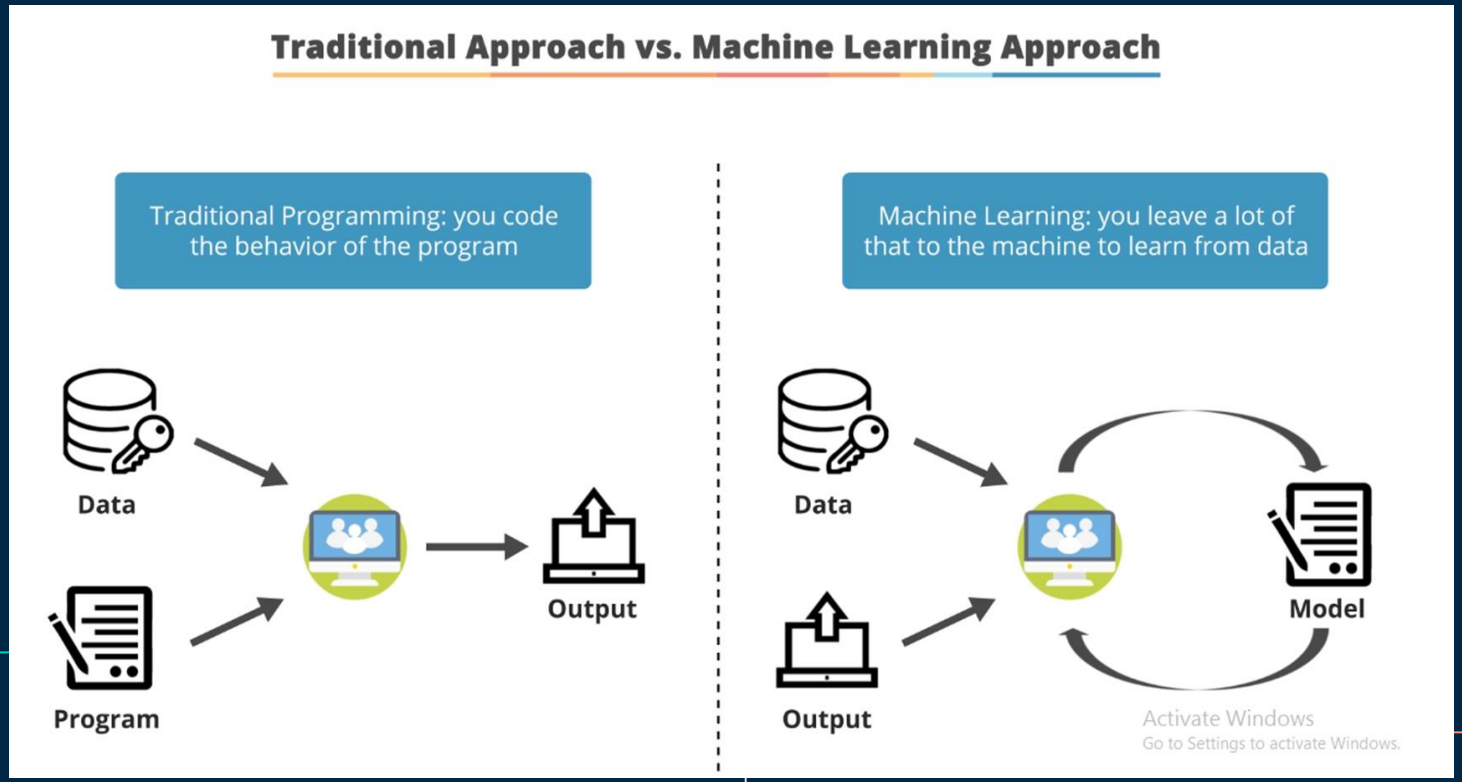
III

The increase of computation power in the past few years and the development of better algorithms.

IV

For example, a wearable fitness tracker like Fitbit, or an intelligent home assistant like Google Home.

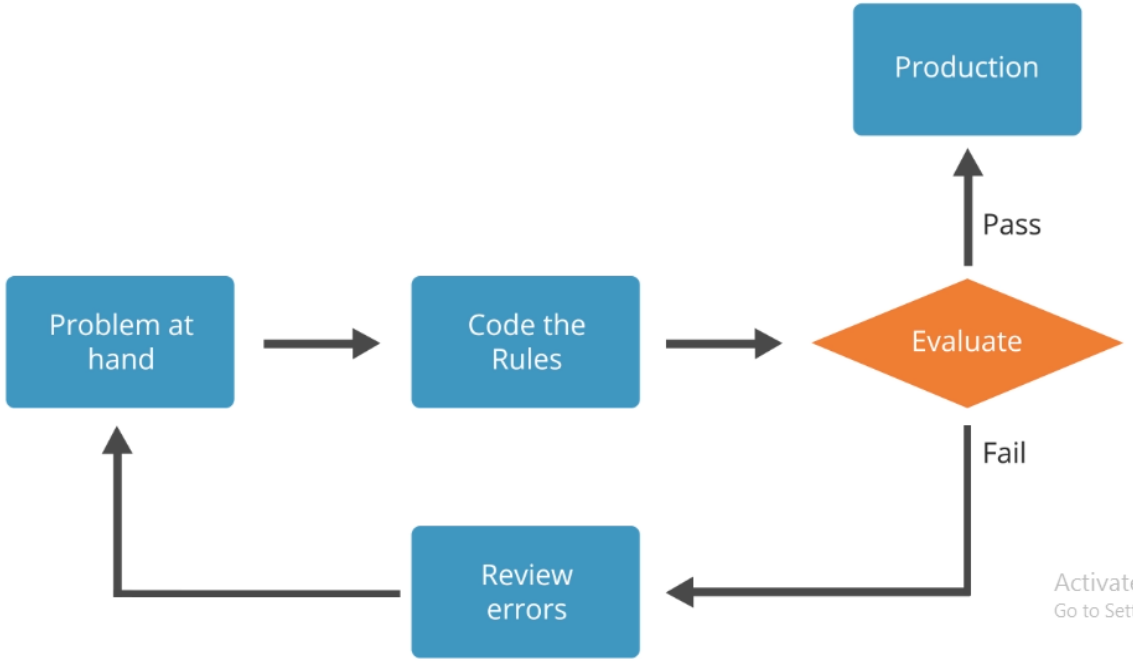
Machine Learning Vs Traditional Programming



Problem Solving Approach

Traditional Approach

Traditional programming relies on hard-coded rules.



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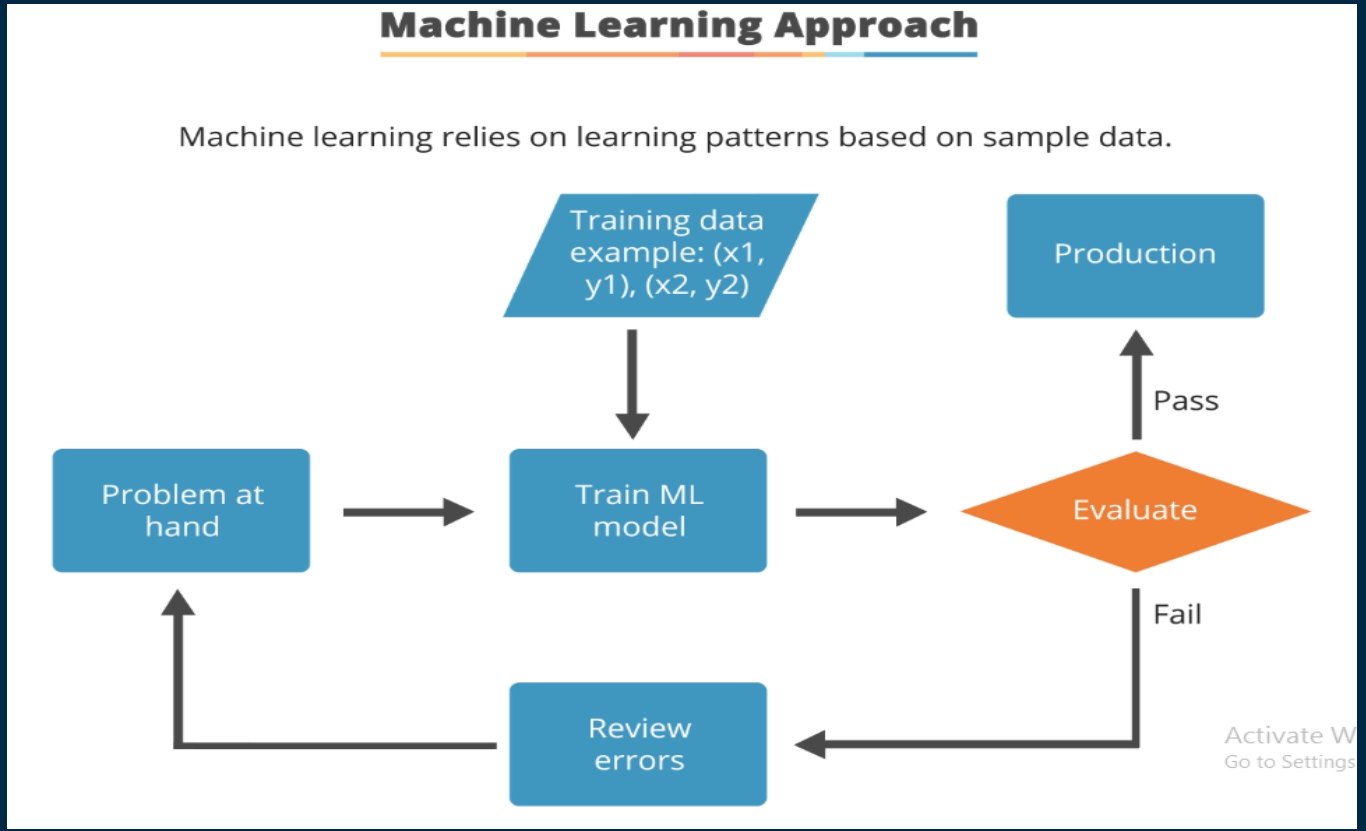
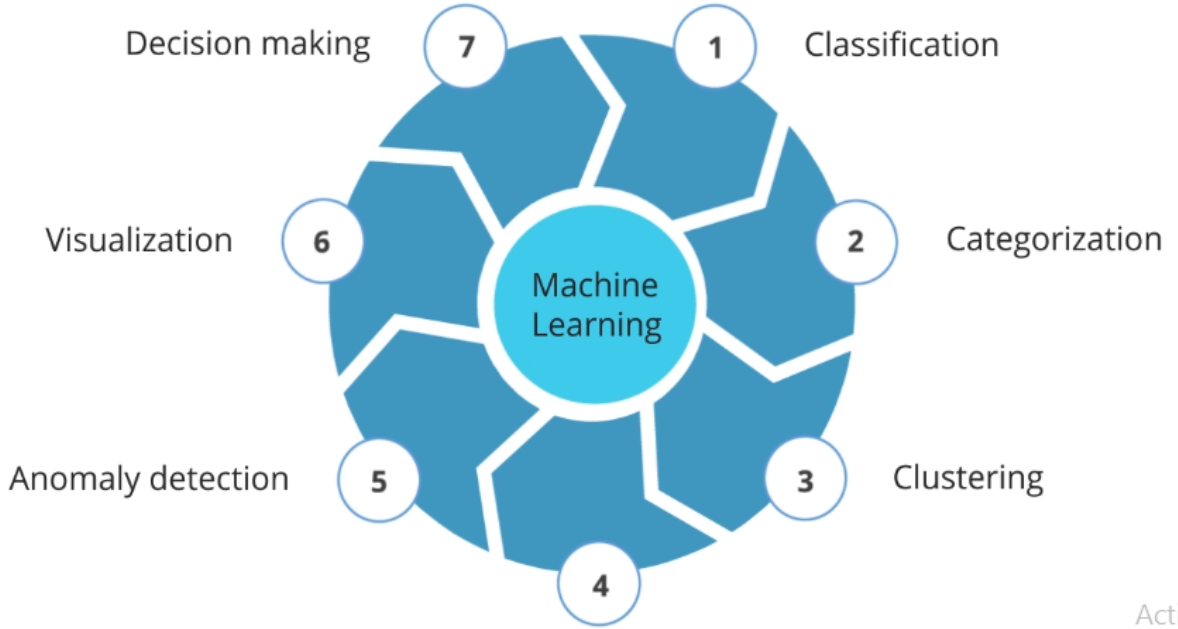
Machine Learning Approach



Machine Learning Techniques

Machine learning uses a number of theories and techniques from data science:



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Machine Learning Techniques

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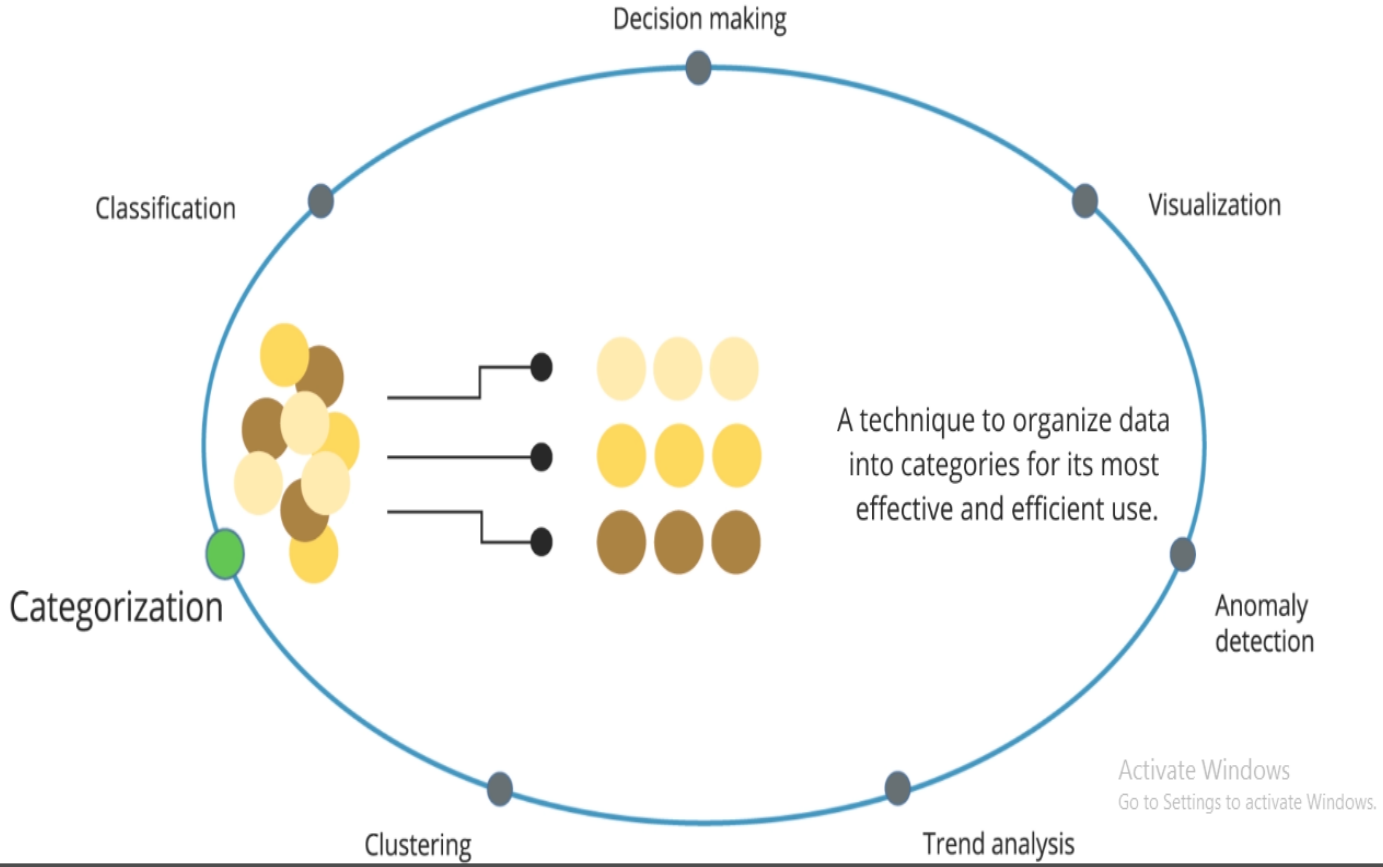
Machine Learning Techniques



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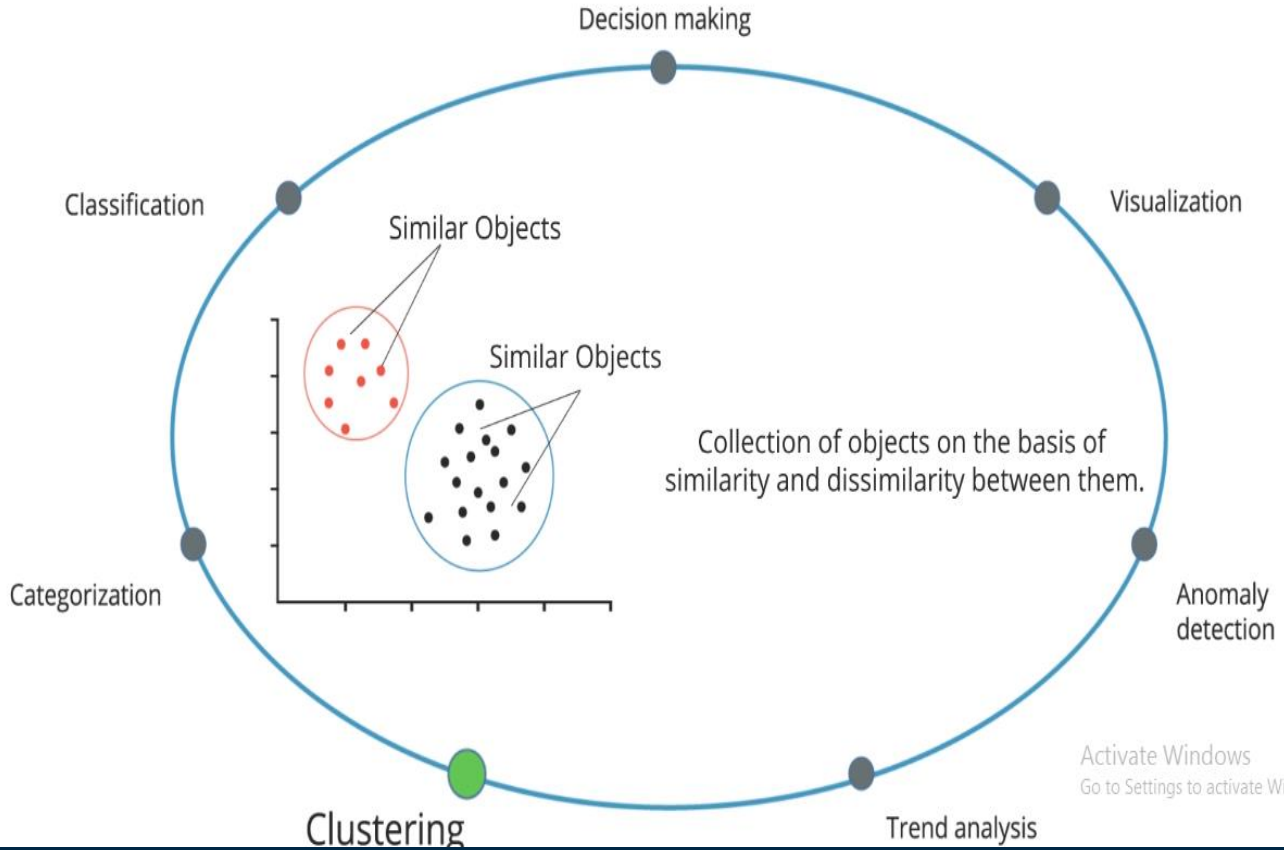
Classification vs Clustering

Criteria	Classification	Clustering
Prior Knowledge of classes	Yes	No
Use case	Classify new sample into known classes	Suggest groups based on patterns in data
Algorithms	Decision Trees, Bayesian classifiers	K-means, Expectation Maximization
Data Needs	Labeled samples from a set of classes	Unlabeled samples

Machine Learning Techniques



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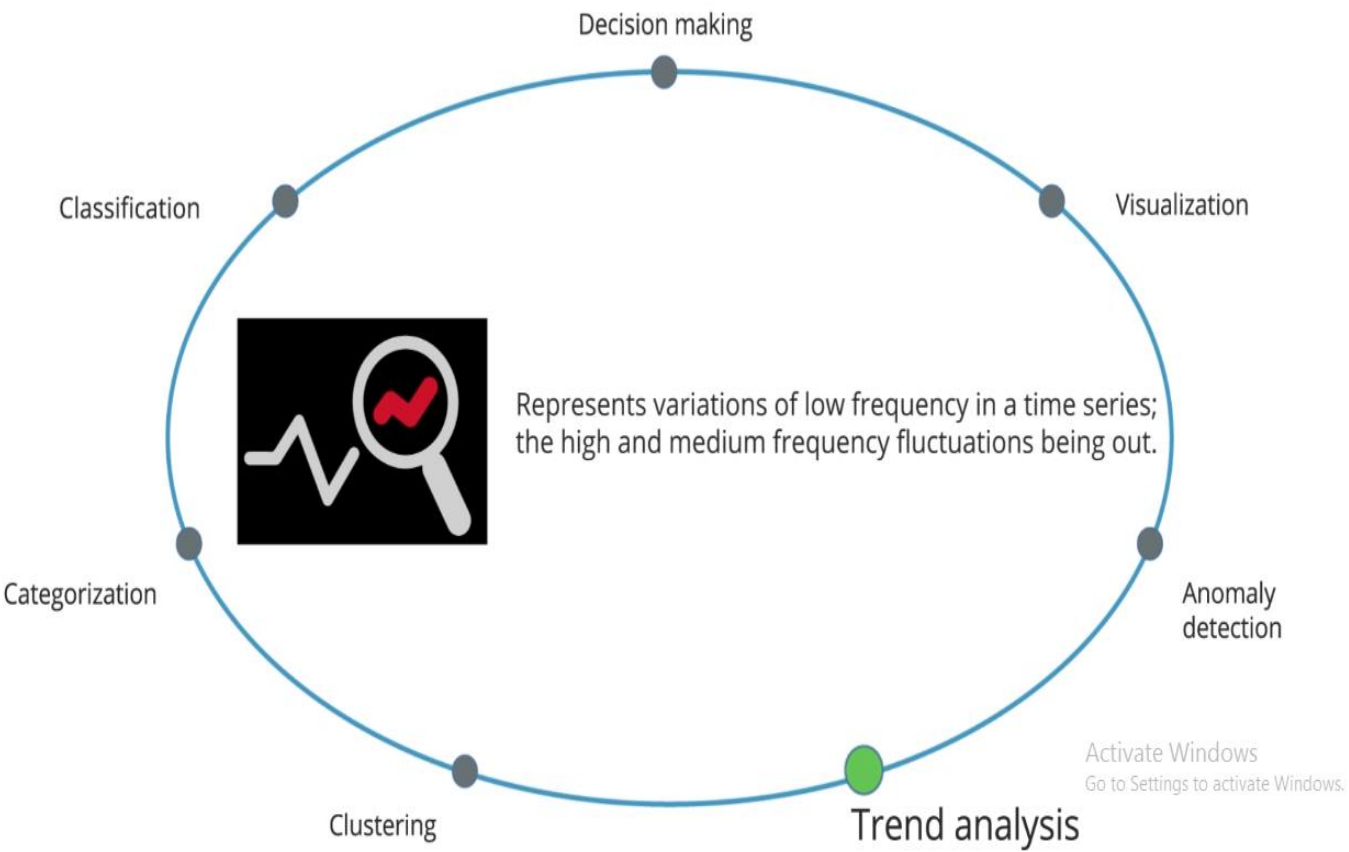
	CLUSTERING	CLASSIFICATION
PREDEFINED	Unlike classification, clusters are not predefined.	Usually in classification you have a set of predefined classes.
APPROACH	Clustering is an unsupervised learning approach.	Classification is a supervised learning.
LABEL & TRAINING	Clustering does not use labeled data or a training set.	Classifies new data based on observations from the training set. The training set is labeled.
ALGORITHMS	K-means clustering and hierarchical clustering algorithms are most popular.	K-Nearest Neighbor and decision tree algorithms are most popular.
COMPLEXITY	Less complex as compared to classification.	Highly complex as compared to clustering.

Machine Learning Techniques



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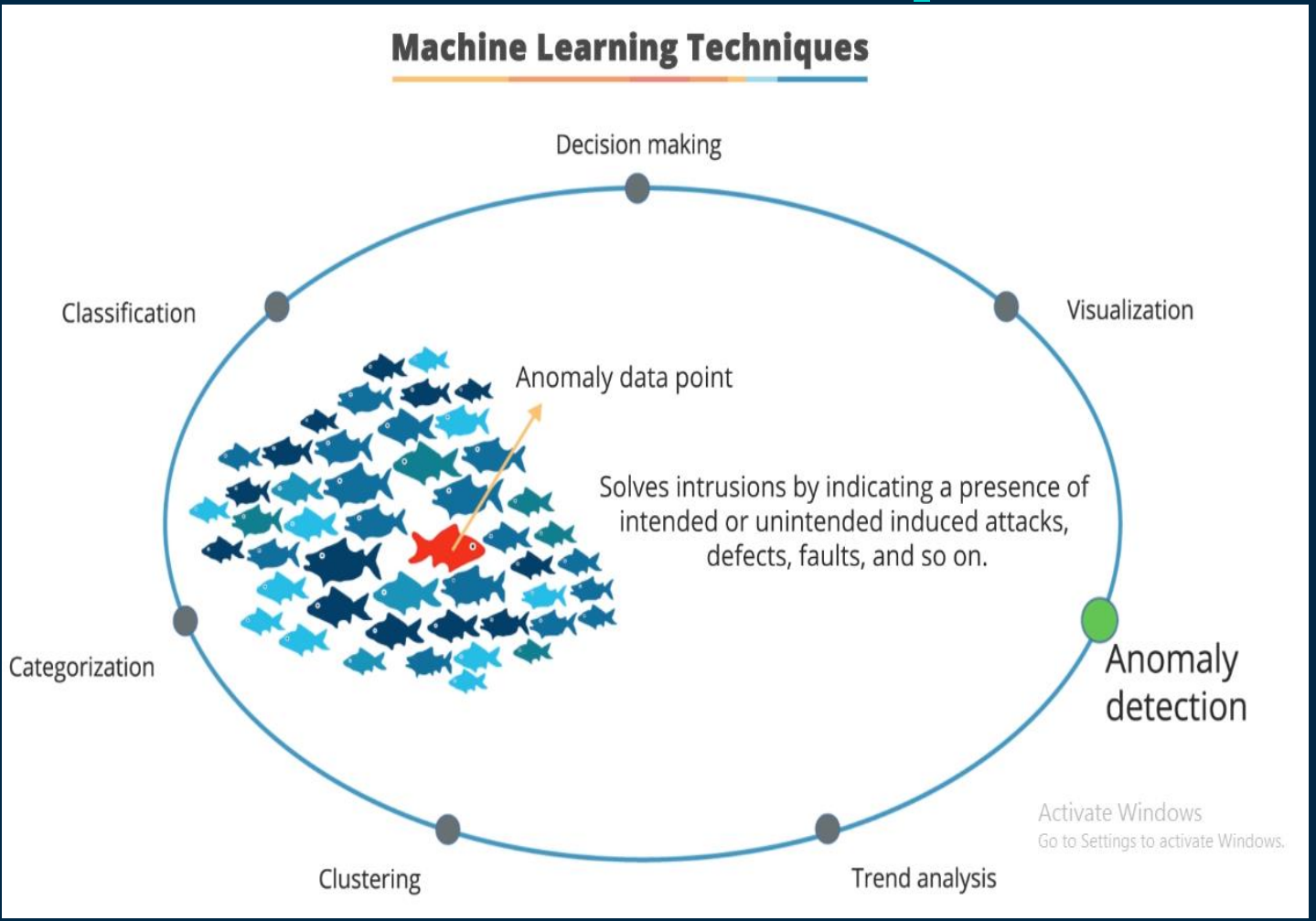
Machine Learning Techniques



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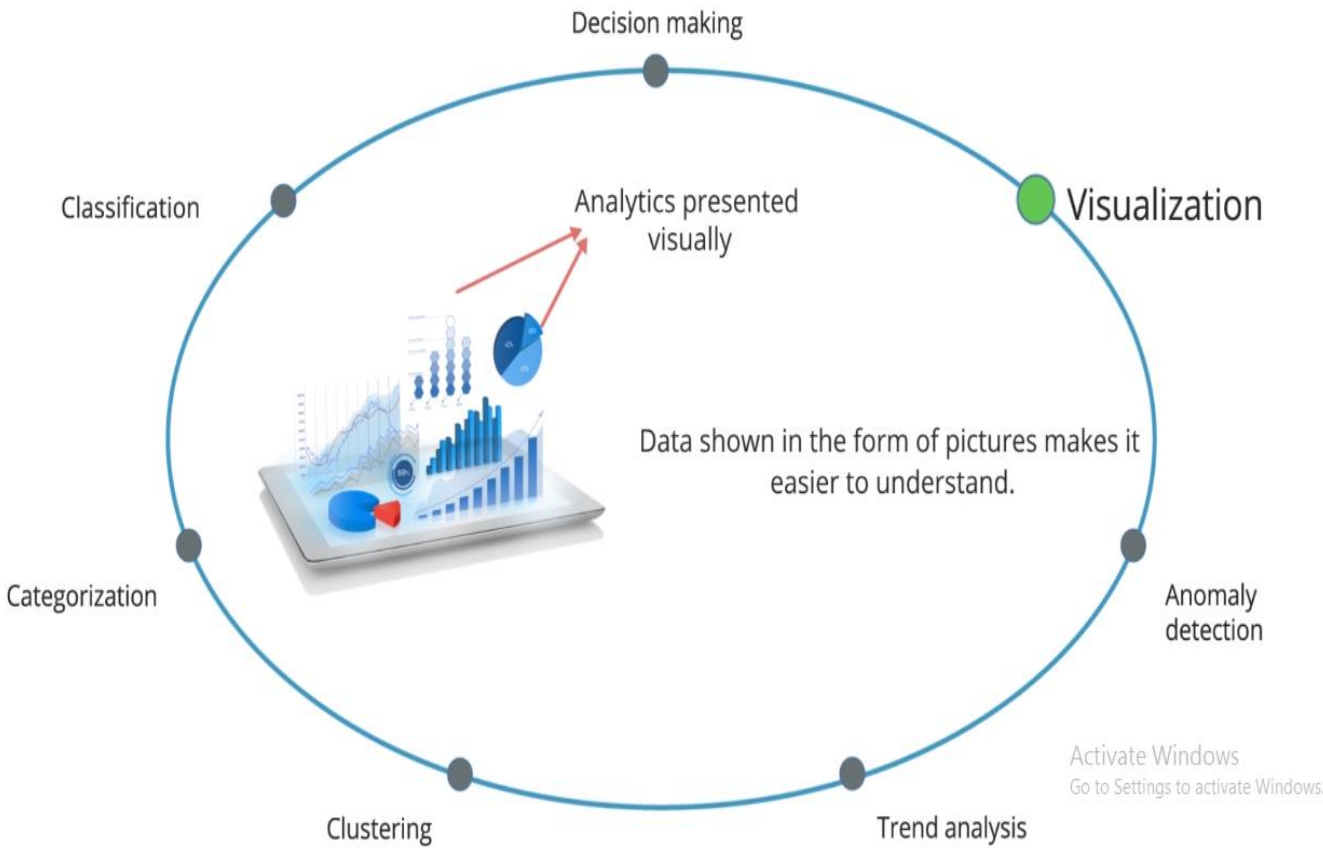
Machine Learning Techniques



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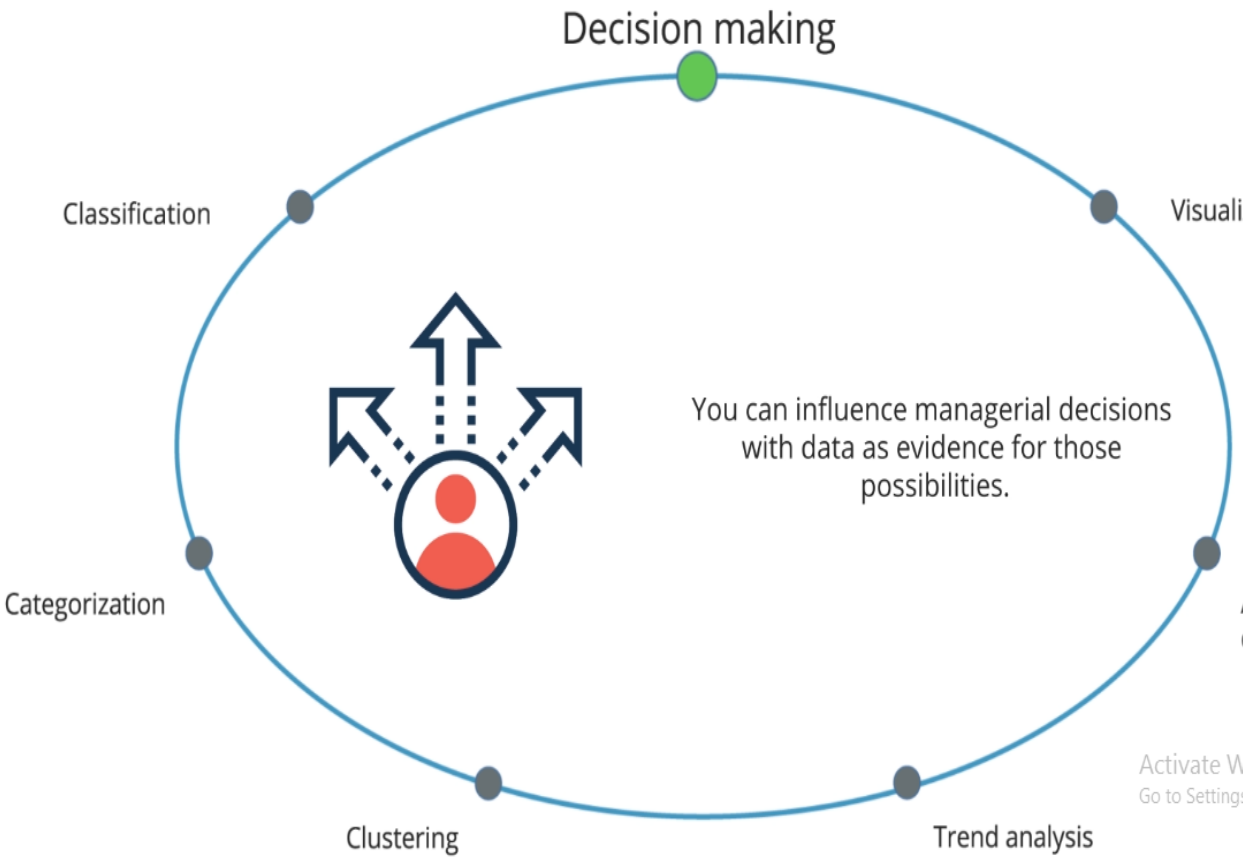
Machine Learning Techniques



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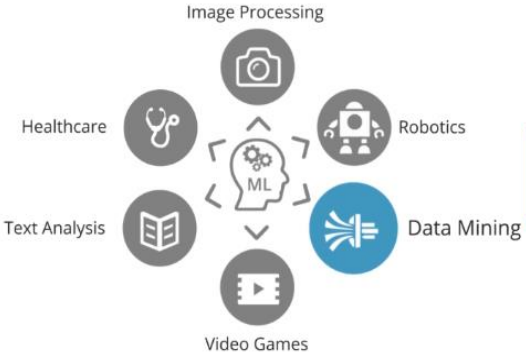
APPLICATION OF MACHINE LEARNING – PART B

Machine Learning Applications

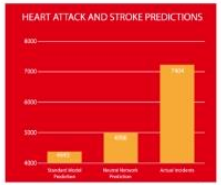
Applications of Machine Learning



It is the method of analyzing hidden patterns in data.

Anomaly Detection

Association Rules



Grouping and Predictions

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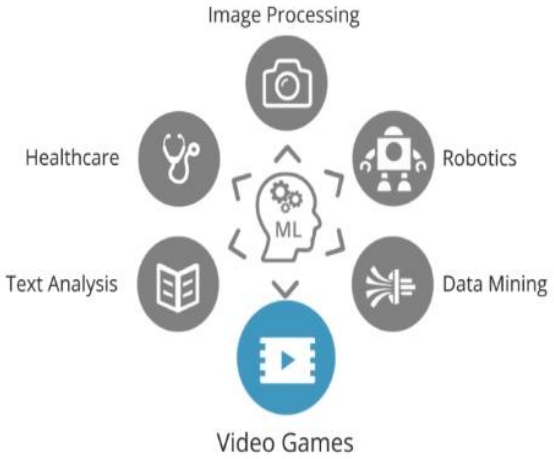
Applications of Machine Learning



A lot of data needs to be considered to predict the winner.

A machine learning classifier will predict the result of the match based on this data.

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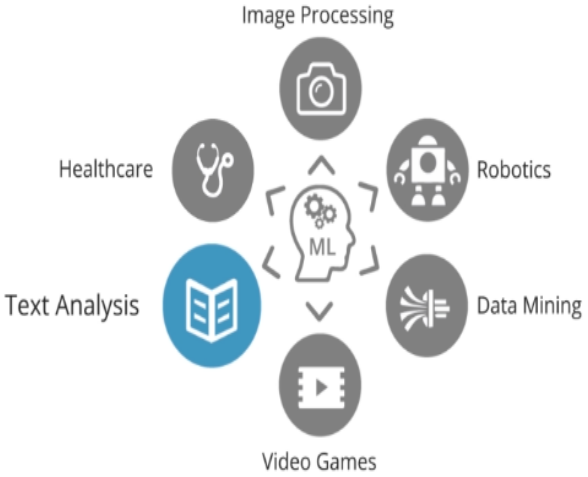
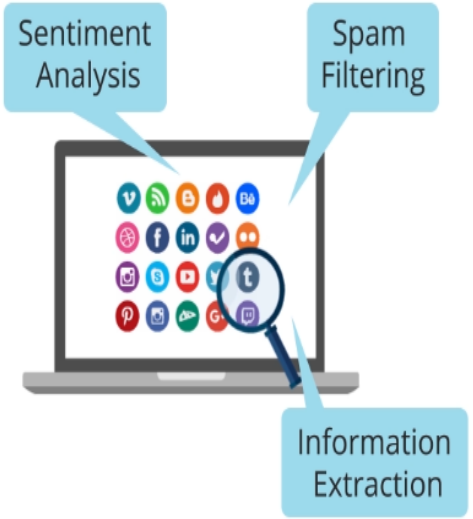
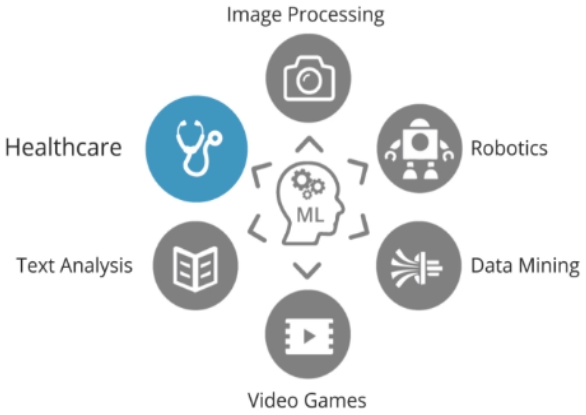
Applications of Machine Learning

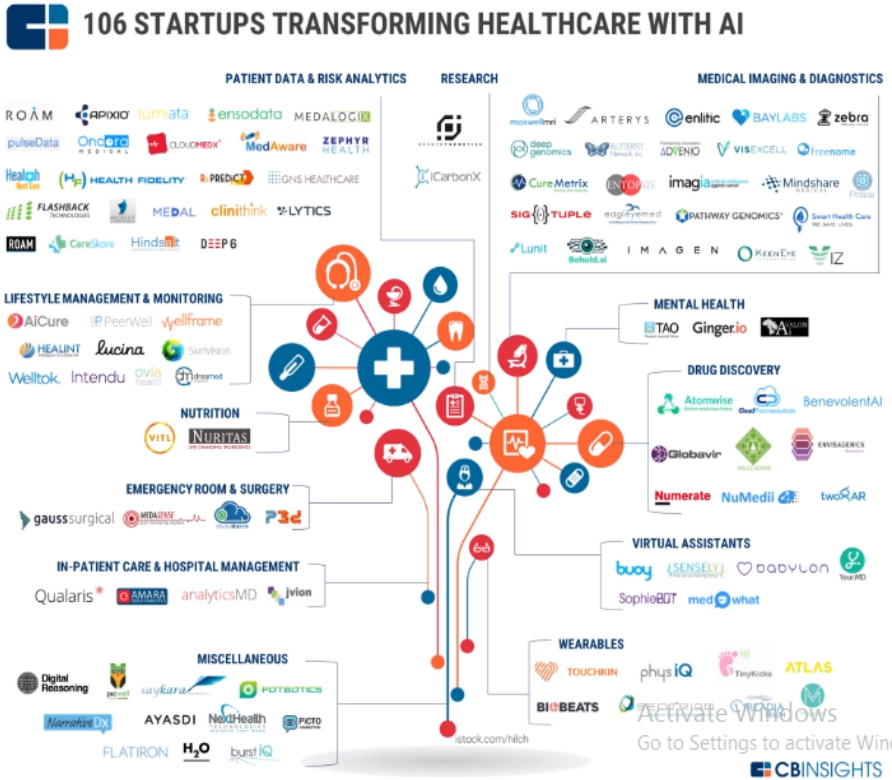


An automated process of obtaining information from text.



Applications of Machine Learning





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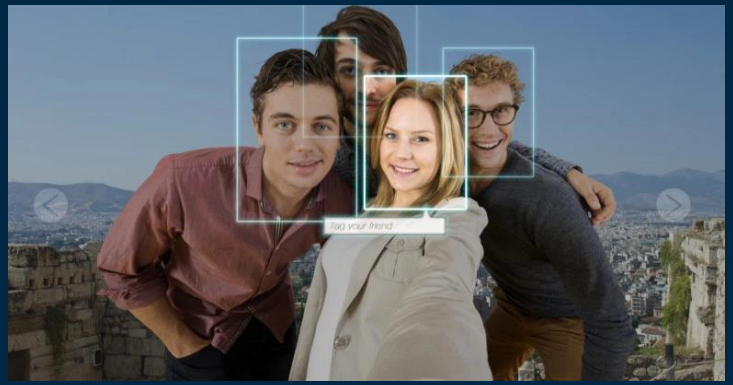
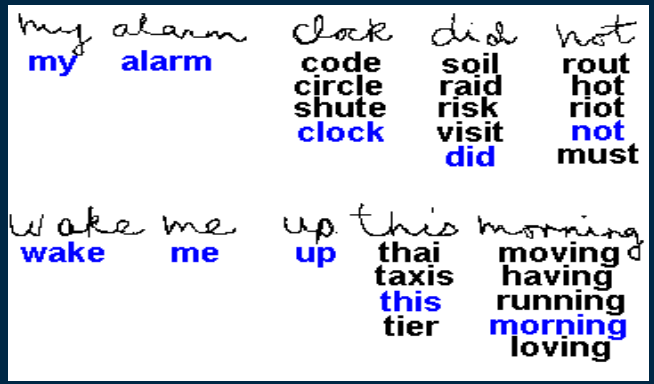
MACHINE LEARNING Applications

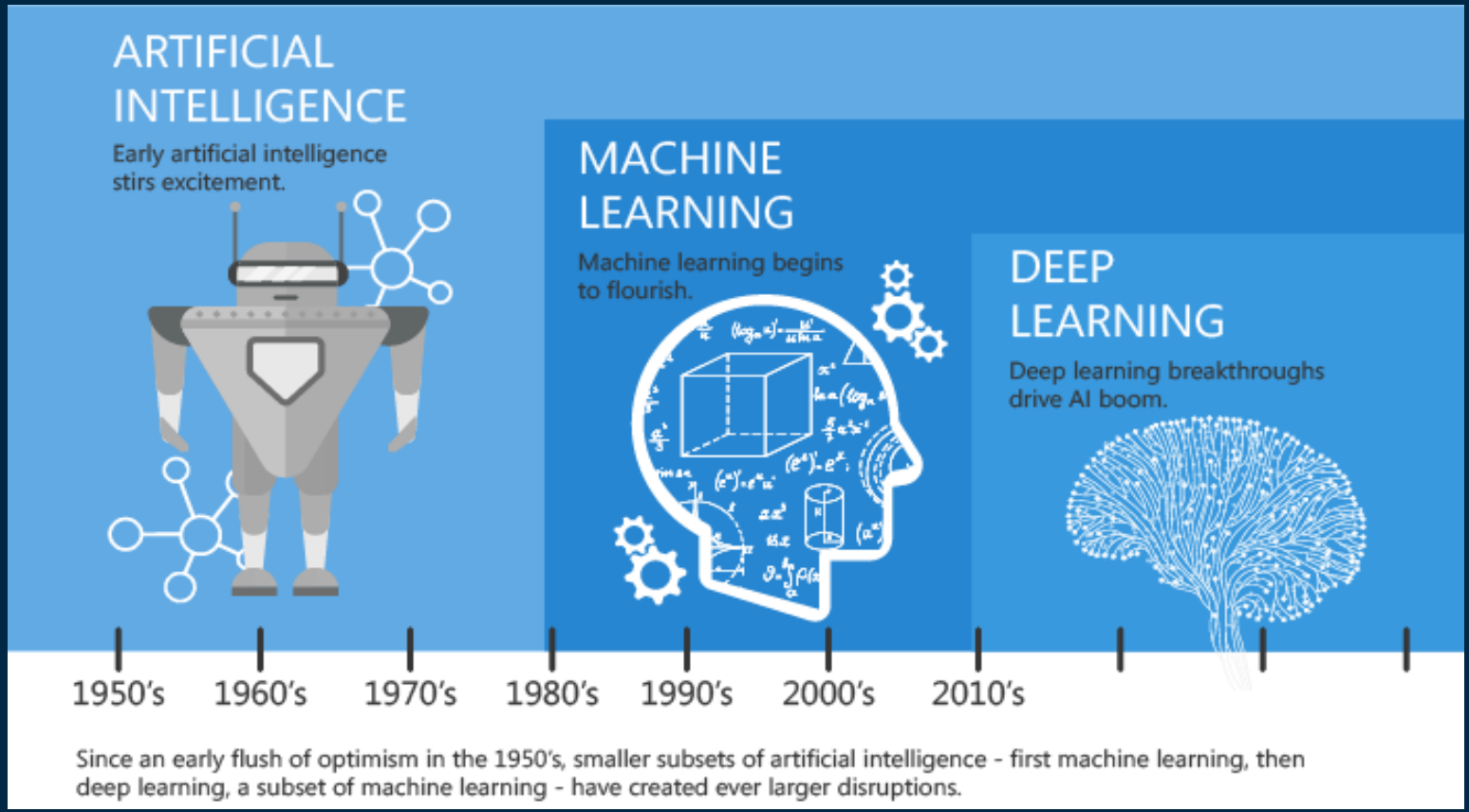
1. **Prediction** — Machine learning can also be used in the prediction systems. Considering the loan example, to compute the probability of a fault, the system will need to classify the available data in groups.
2. **Image recognition** — Machine learning can be used for face detection in an image as well. There is a separate category for each person in a database of several people.
3. **Speech Recognition** — It is the translation of spoken words into the text. It is used in voice searches and more. Voice user interfaces include voice dialing, call routing, and appliance control. It can also be used a simple data entry and the preparation of structured documents.
4. **Medical diagnoses** — ML is trained to recognize cancerous tissues.
5. **Financial industry and trading** — companies use ML in fraud investigations and credit checks.

Some examples of MACHINE LEARNING Applications





History of Machine Learning



Definitions of Machine Learning

- According to Arthur Samuel, Machine Learning algorithms enable the computers to learn from data, and even improve themselves, without being explicitly programmed.

- Machine learning (ML) is a category of an algorithm that allows software applications to become more accurate in predicting outcomes without being explicitly programmed.

- The basic premise of machine learning is to build algorithms that can receive input data and use statistical analysis to predict an output while updating outputs as new data becomes available.

Understudying of Machine Learning Algorithms

Training data consists of inputs, also known as features, and output, also known as label.

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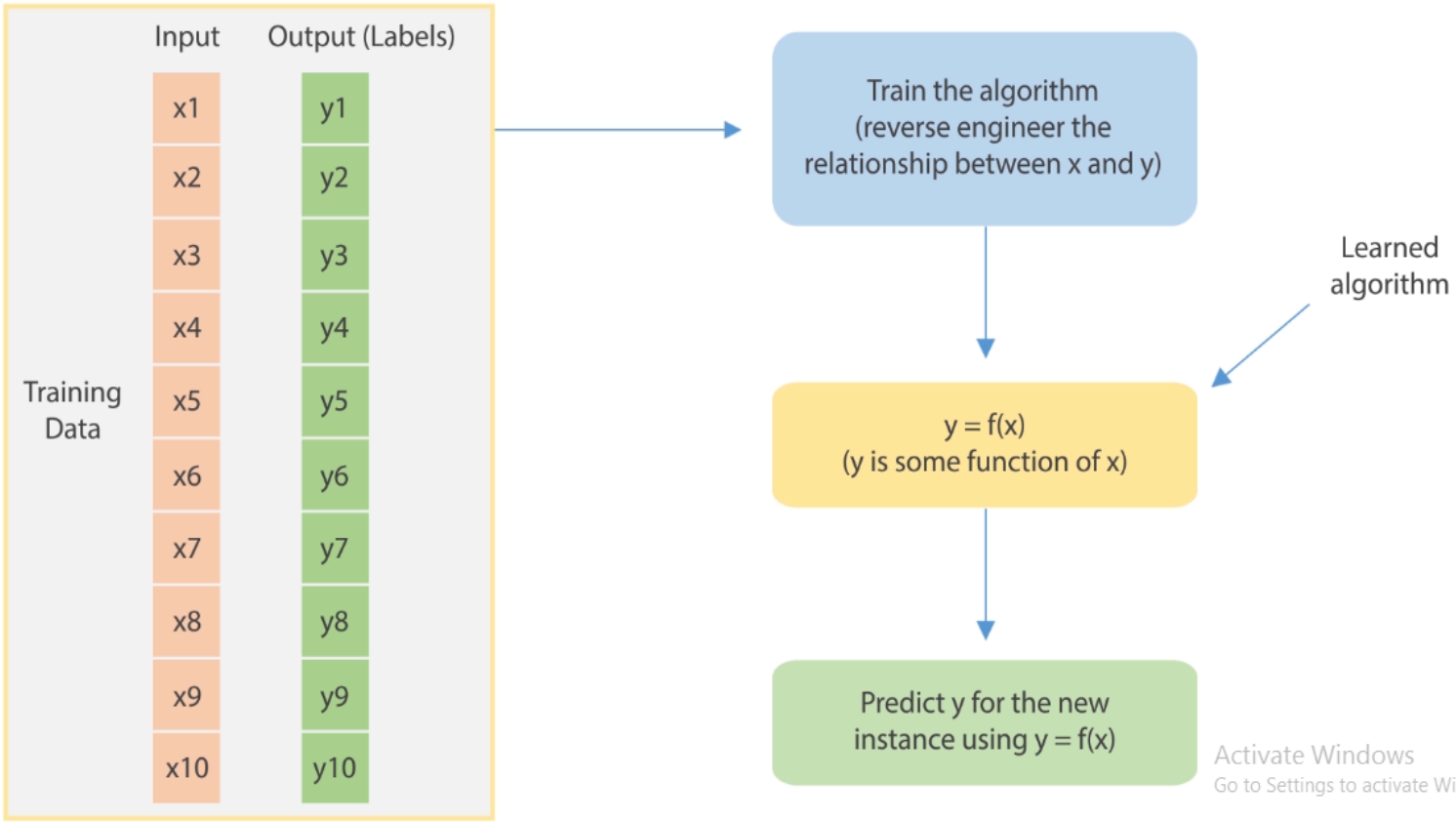
Apple

Understanding the Algorithm



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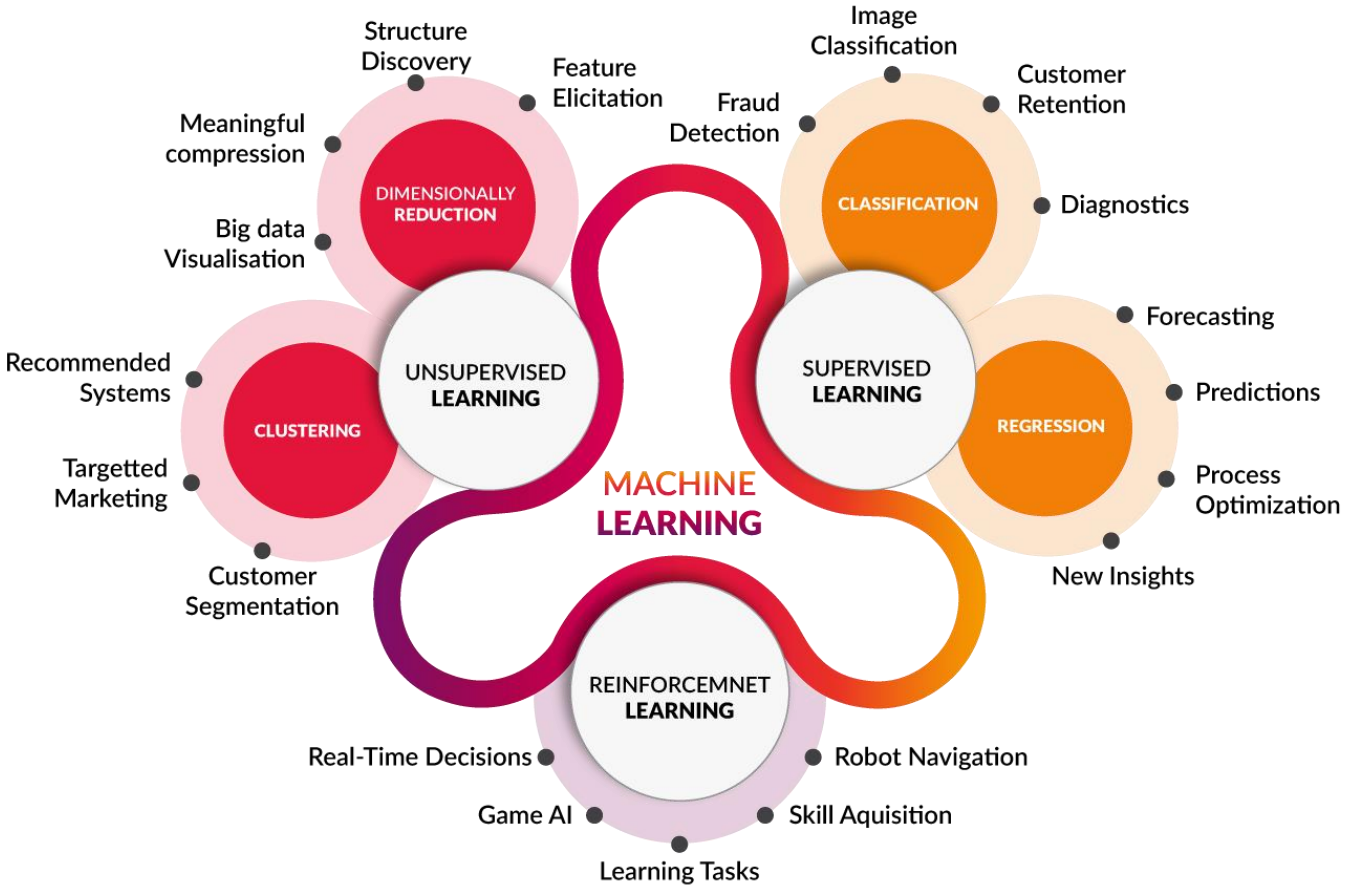
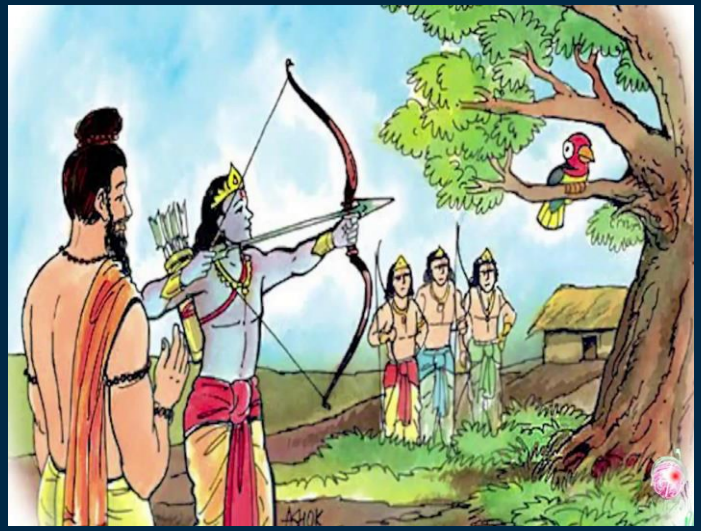
Types of Machine Learning



Types of Machine Learning

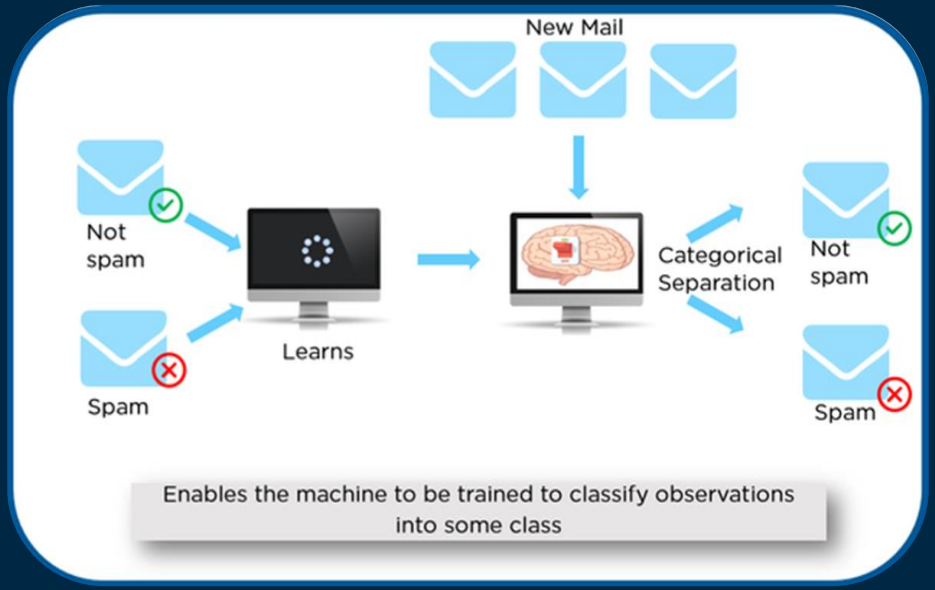
Supervised Learning

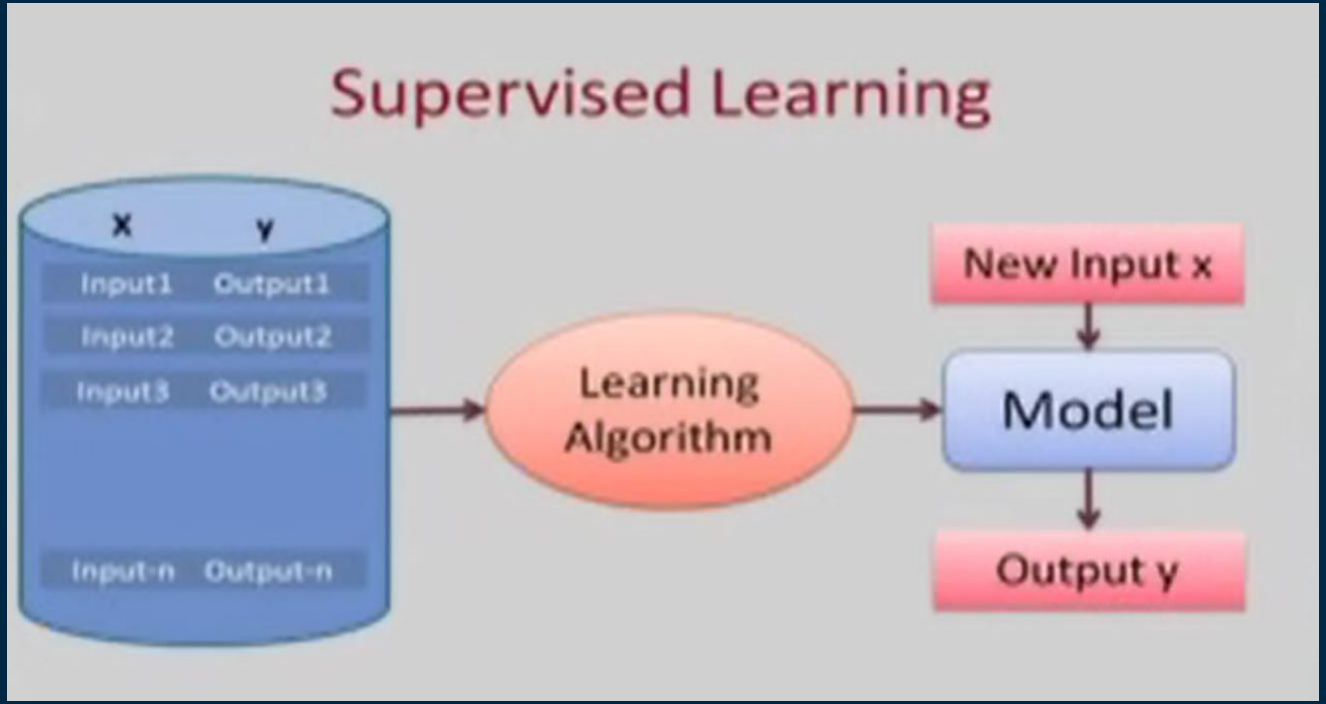


Unsupervised Learning

Supervised Learning Algorithm

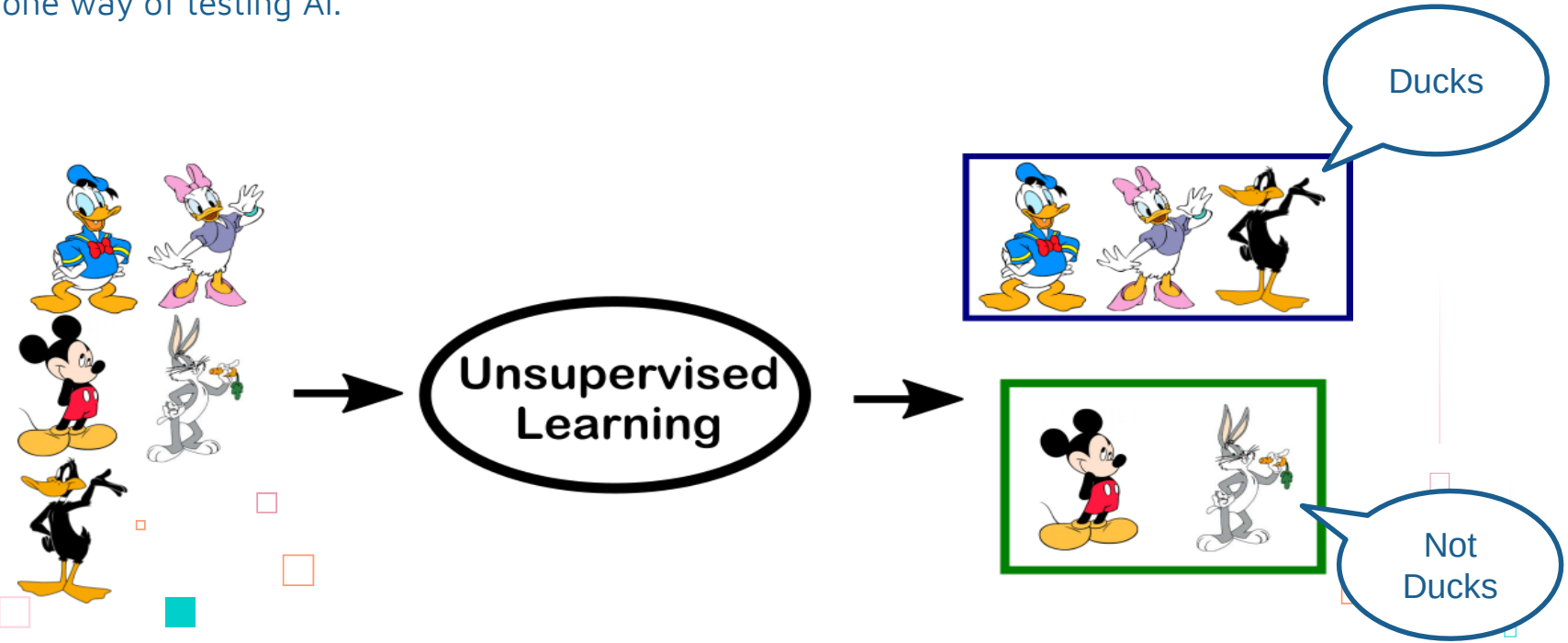
- In Supervised learning, an AI system is presented with data which is labeled, which means that each data tagged with the correct label.
- The goal is to approximate the mapping function so well that when you have new input data (x) that you can predict the output variables (Y) for that data.



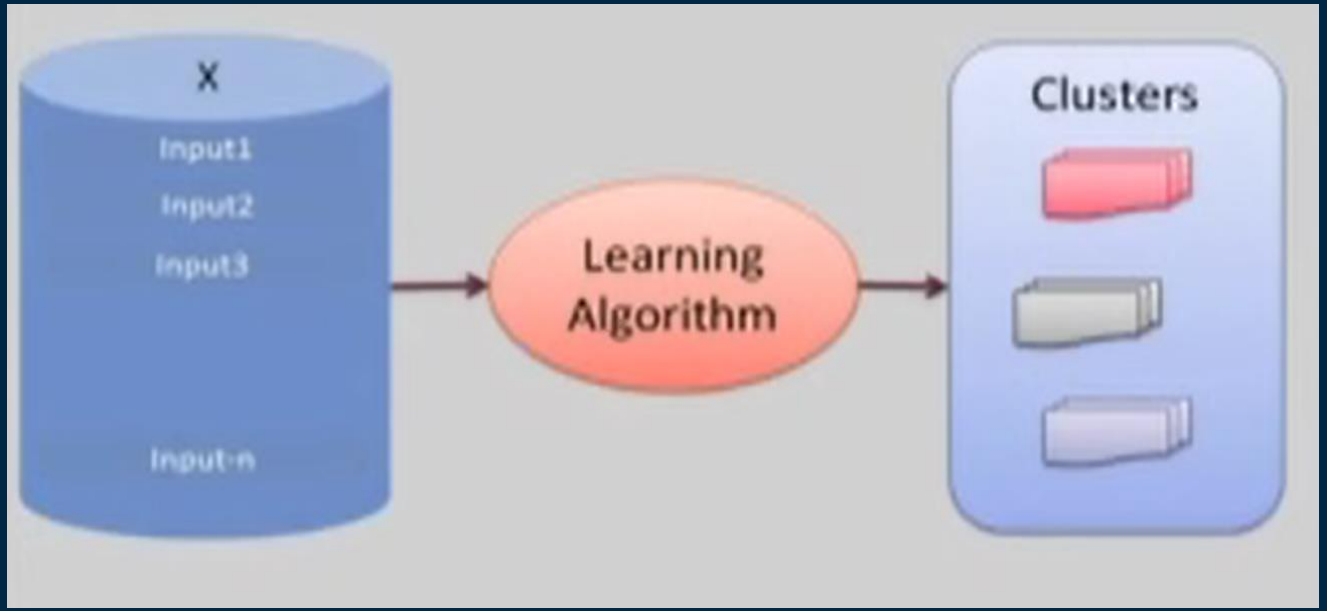

Supervised Learning
x
y
Input1
Output1
Input2
Output2
Input3
Output3
Input-n
Output-n
Learning Algorithm
New Input x
Model
Output y

Unsupervised Learning Algorithm

In Unsupervised Learning, an AI system is presented with unlabeled, uncategorized data and the system's algorithms act on the data without prior training. The output is dependent upon the coded algorithms. Subjecting a system to unsupervised learning is one way of testing AI.

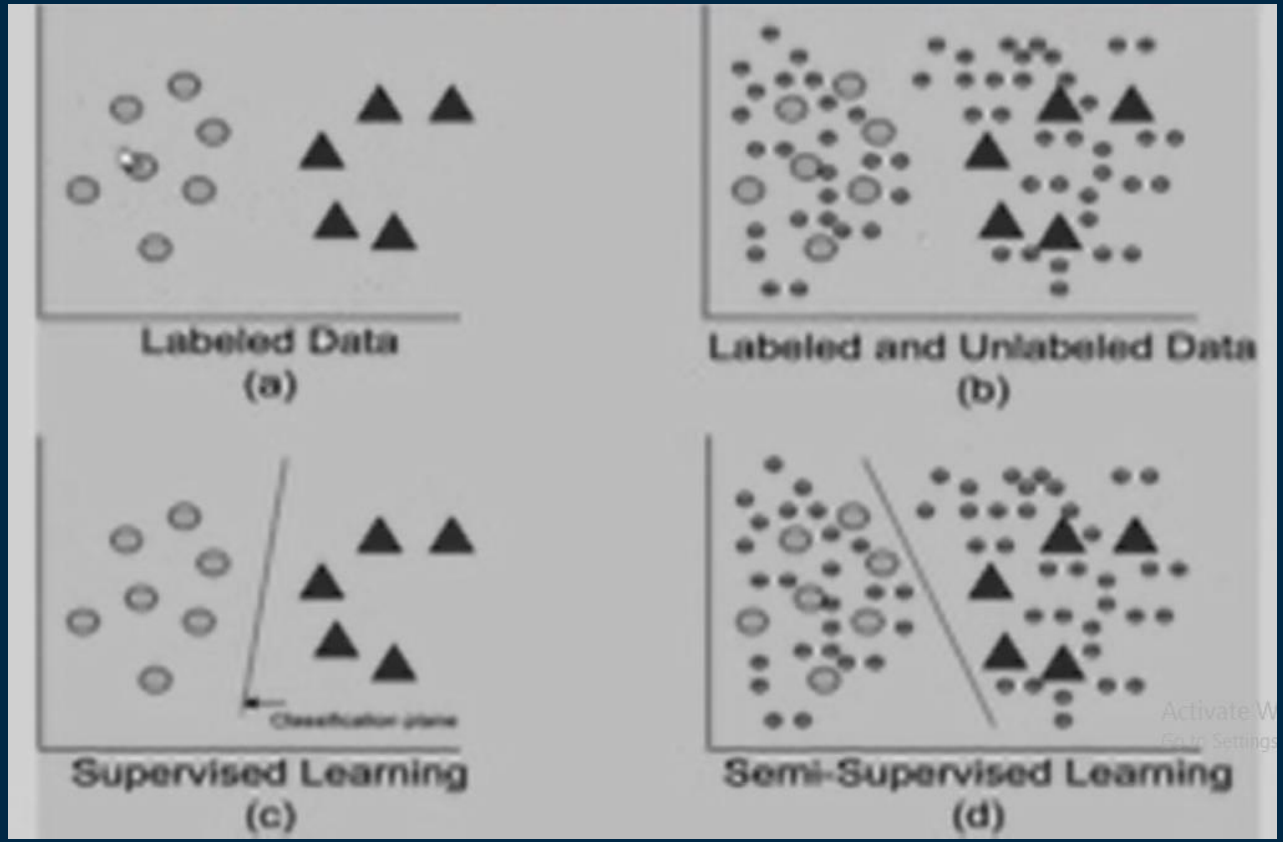


Unsupervised Learning Algorithm



Exp: In class , make a group of students on the basis of Height .

Semi-supervised Learning Algorithm



Reinforcement Learning

01

A reinforcement learning algorithm, learns by interacting with its environment.

02

It receives rewards by performing correctly and penalties for performing incorrectly.

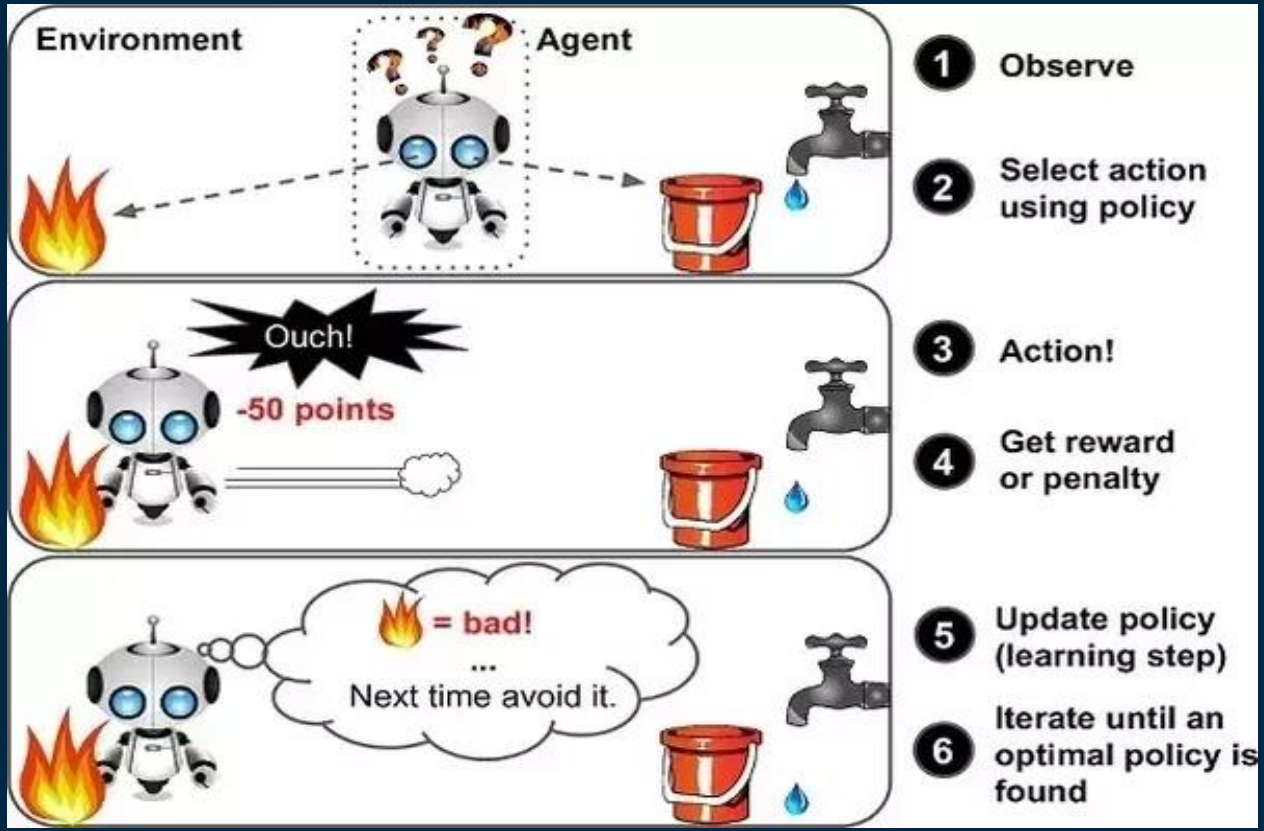
03

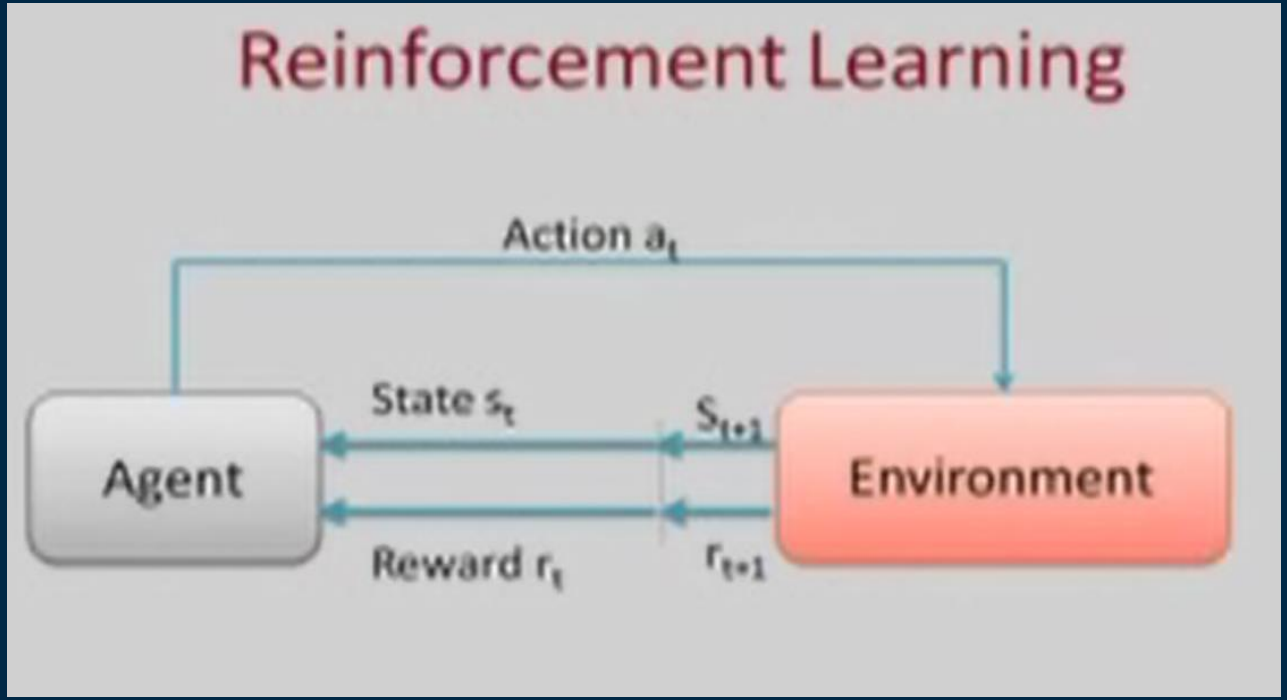
It learns without intervention from a human by maximizing its reward and minimizing its penalty.

04

It is a type of dynamic programming that trains algorithms using a system of reward and punishment

Reinforcement Learning




Reinforcement Learning
Action a_t
State s_t
S_{t+1}
Agent
Environment
Reward r_t
r_{t+1}

LEARNING PROBLEMS

1. In general, to have a well-defined learning problem, we must identity these three features:
2. the class of tasks (T)
3. the measure of performance to be improved (P),
4. and the source of experience (E).
5. A checkers learning problem:

   Task T: playing checkers

   Performance measure P: percent of games won against opponents

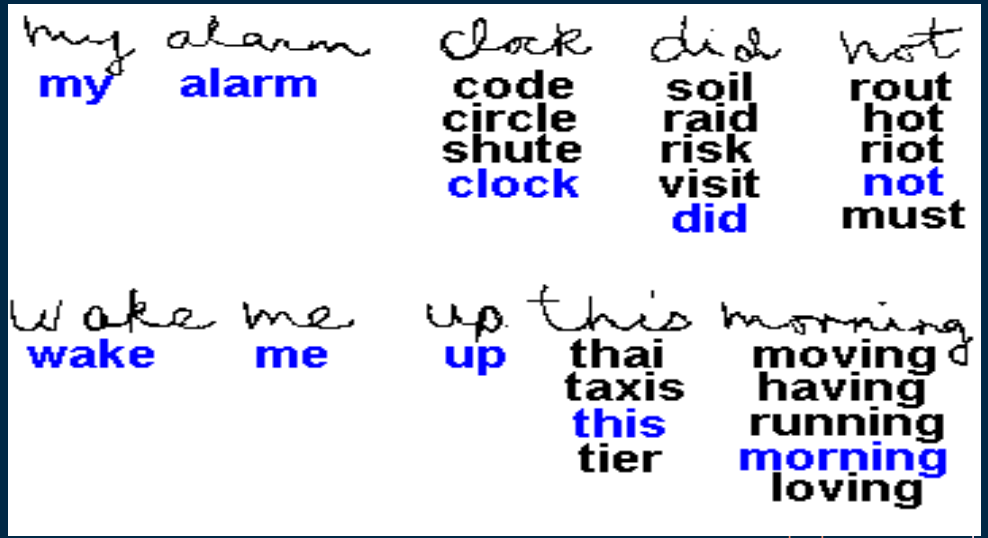
   Training experience E: playing practice games against itself

6. A handwriting recognition learning problem:

Task T: recognizing and classifying handwritten words within sentence

Performance measure P: percent of words correctly classified

Training experience E: a database of handwritten words with given classifications



7. A robot driving learning problem:

Task T: driving on public four-lane highways using vision sensors

Performance measure P: aver distance traveled before an error (as judged by human overseer)

Training experience E: a sequence of ims and steering commands recorded while observing a human driver

Key Elements of Machine Learning

1. Every machine learning algorithm has three components:
2. Representation: how to represent knowledge.
3. Examples include decision trees, sets of rules, instances, graphical models, neural networks, support vector machines, model ensembles and others.
4. Evaluation: the way to evaluate candidate programs (hypotheses).
5. Examples include accuracy, prediction and recall, squared error, likelihood, posterior probability, cost, margin, entropy k-L divergence and others.
6. Optimization: the way candidate programs are generated known as the search process.
7. For example combinatorial optimization, convex optimization, constrained optimization.

Working with Machine Learning Algorithms

1. Start Loop
2. Understand the domain, prior knowledge and goals. Talk to domain experts. Often the goals are very unclear. You often have more things to try then you can possibly implement.
3. Data integration, selection, cleaning and pre-processing. This is often the most time consuming part. It is important to have high quality data. The more data you have, the more it sucks because the data is dirty. Garb in, garb out.
4. Learning models. The fun part. This part is very mature. The tools are general
5. Interpreting results. Sometimes it does not matter how the model works as long it delivers results. Other domains require that the model is understandable. You will be challenged by human experts.
6. Consolidating and deploying discovered knowledge. The majority of projects that are successful in the lab are not used in practice. It is very hard to get something used.
7. End Loop

Supervised Learning

Supervised Learning

Given:

- a set of input features $X_1, \ldots, X_n$
- A target feature Y
- a set of training examples where the values for the input features and the target features are given for each example
- a new example, where only the values for the input features are given

Predict the values for the target features for the new example.

- classification when Y is discrete
- regression when Y is continuous

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Supervised Learning

	X1	X2	X3	X4 ……Xn	Y
I1	A1	A2	A3	A4 ……An	Y1
I2	B1	B2	B3	B4……Bn	Y2
I3	C1	C2	C3	C4……CN	Y3
I4	D1	D2	D3	D4……Dn	Y4
.					.
.					.
.					.
.					
In					

If Y is discrete value feature , then we called Classification problem .
Exp: Rain today Or Not

And If Y is continues value feature , then we called Regression problem.
Exp: House price prediction system

Supervised Learning

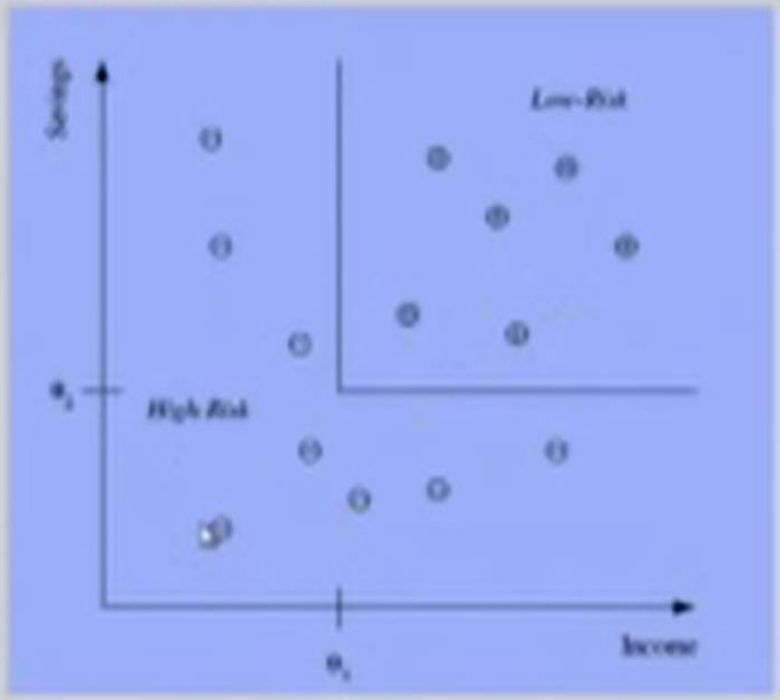
	Math	Phy	Chm	Eng	Y
I1	28	35	40	38	P
I2	37	41	35	33	P
I3	44	39	20	24	F
I4	22	33	29	23	F

Let us consider, X std having marks
33 , 43, 38 and 28 , what will be his result ?

Supervised Learning

Classification

Example: Credit scoring

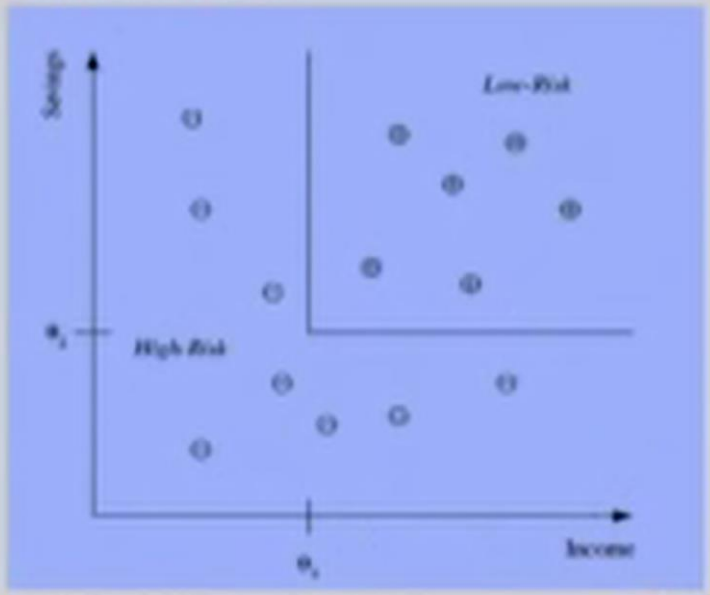


Supervised Learning

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

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Supervised Learning

Regression

Example: Price of a used car

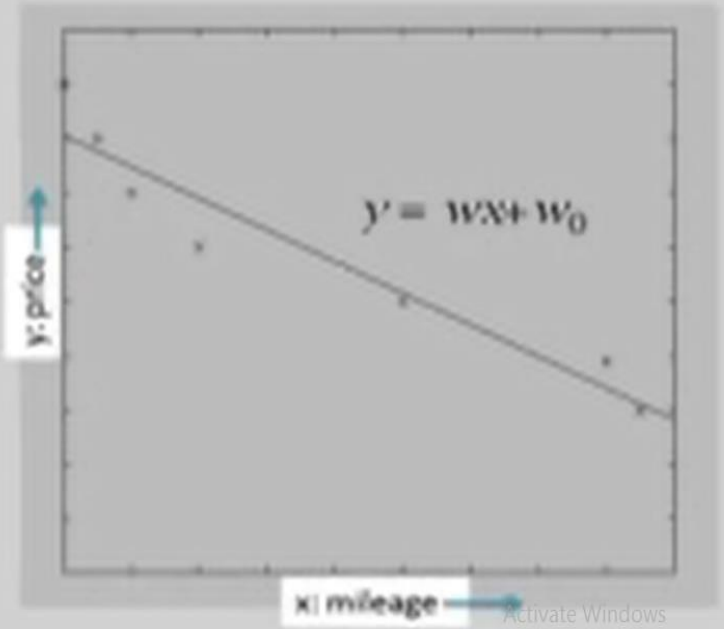
x : car attributes

y : price

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

$g(\ )$ model,

θ parameters



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Features Selection for Machine Learning Algo.

Features

- Often, the individual observations are analyzed into a set of quantifiable properties which are called features. May be
  - categorical (e.g. "A", "B", "AB" or "O", for blood type)
  - ordinal (e.g. "large", "medium" or "small")
  - integer-valued (e.g. the number of words in a text)
  - real-valued (e.g. height)

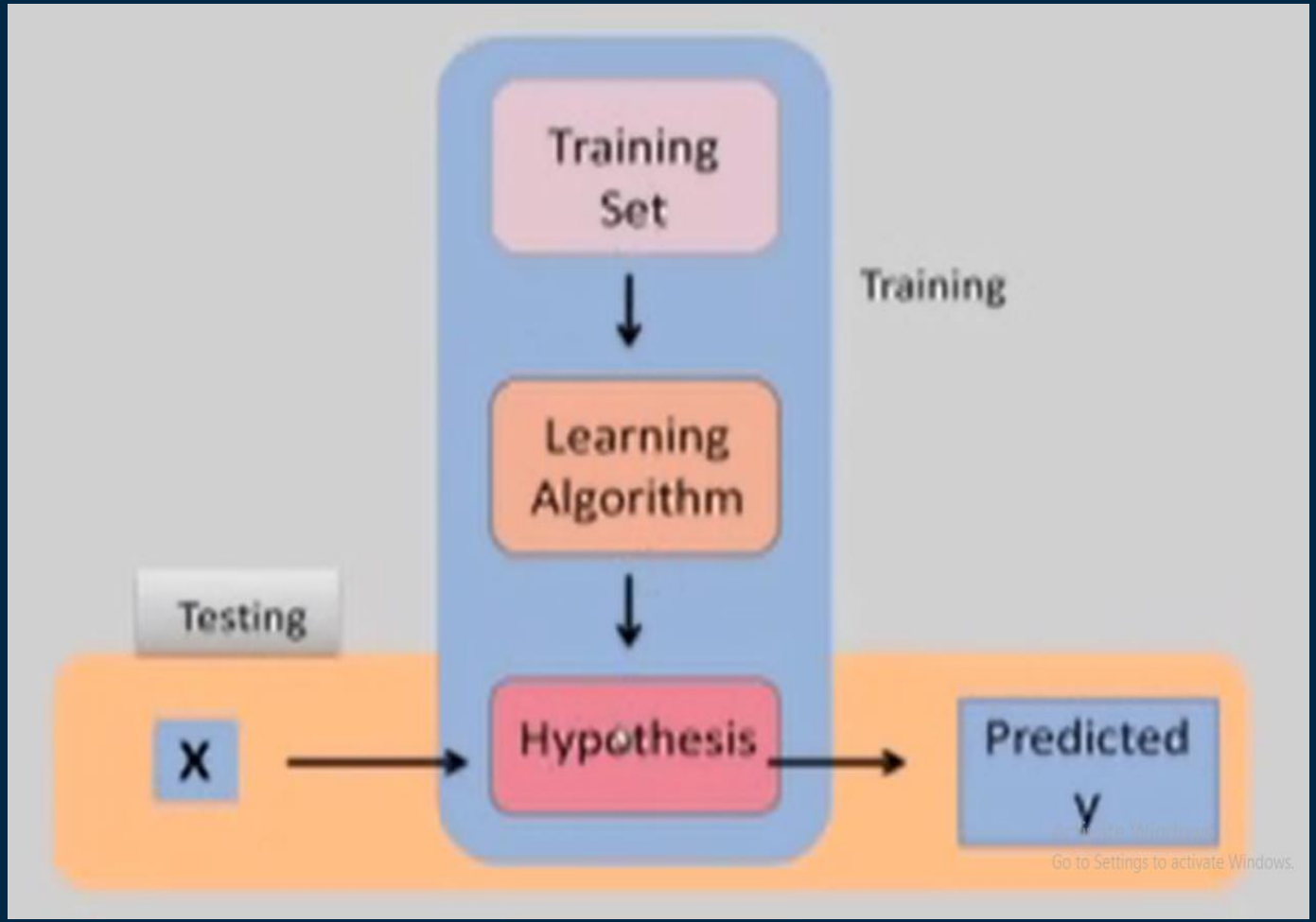
Example Data

Training Examples:

	Action	Author	Thread	Length	Where
e1	skips	known	new	long	Home
e2	reads	unknown	new	short	Work
e3	skips	unknown	old	long	Work
e4	skips	known	old	long	home
e5	reads	known	new	short	home
e6	skips	known	old	long	work

New Examples:

e7	???	known	new	short	work
e8	???	unknown	new	short	work


Training Set
Learning Algorithm
Hypothesis
Training
Testing
X
Predicted y
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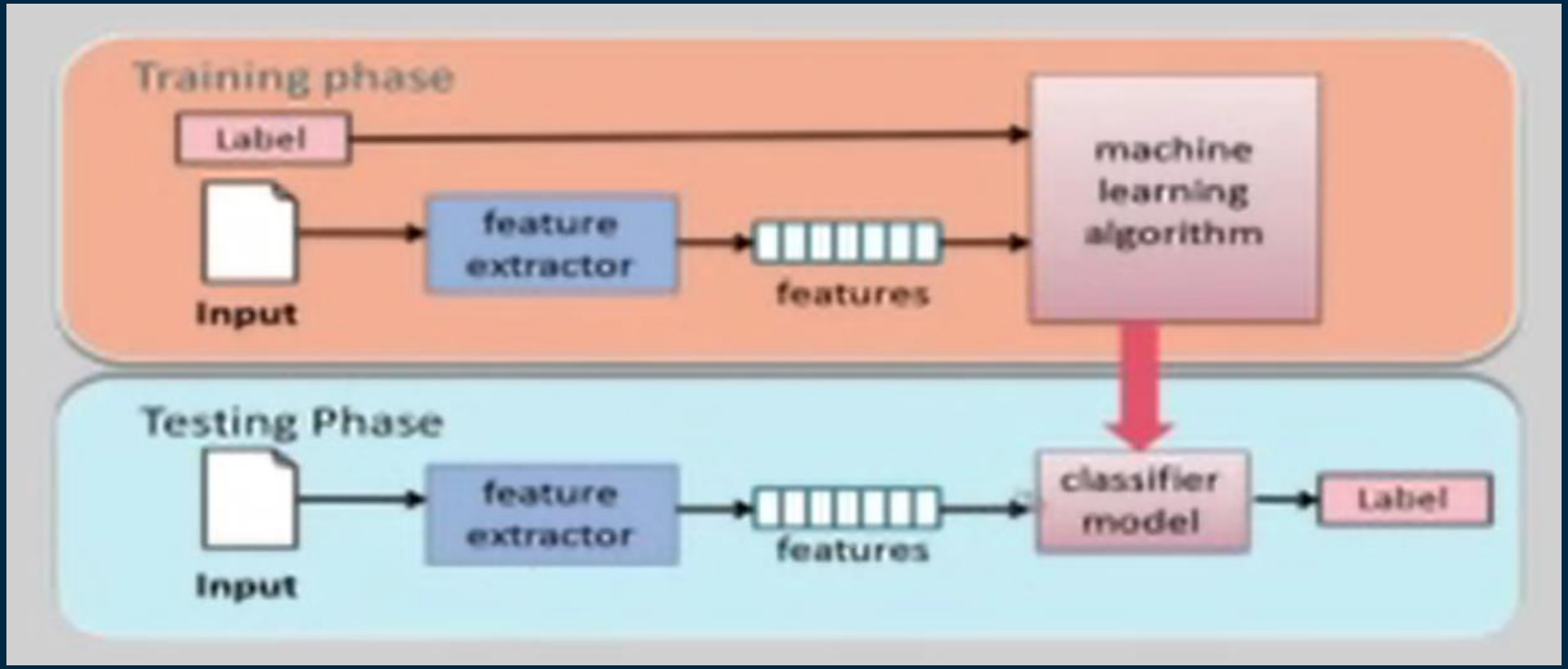
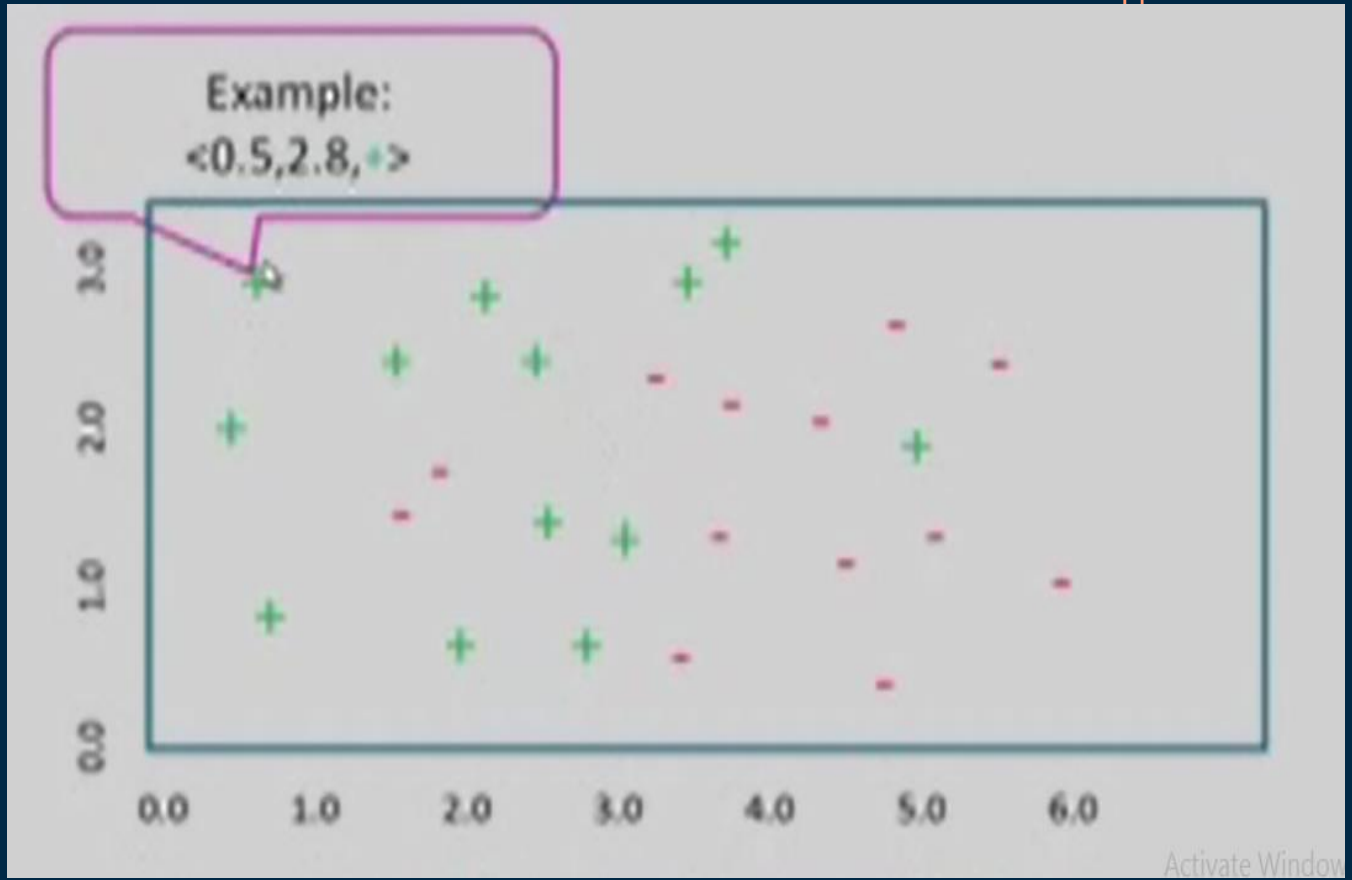
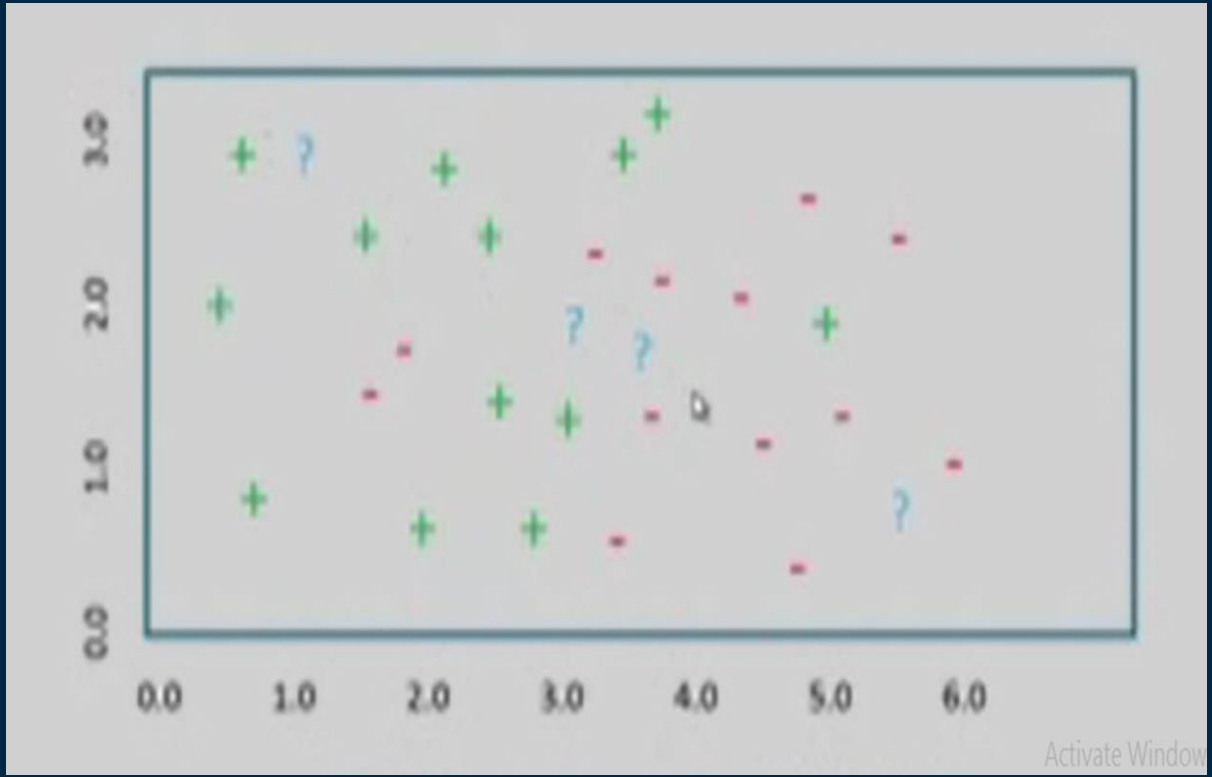

Training phase
Label
Input
feature extractor
features
machine learning algorithm
Testing Phase
Input
feature extractor
features
classifier model
Label

Feature Space

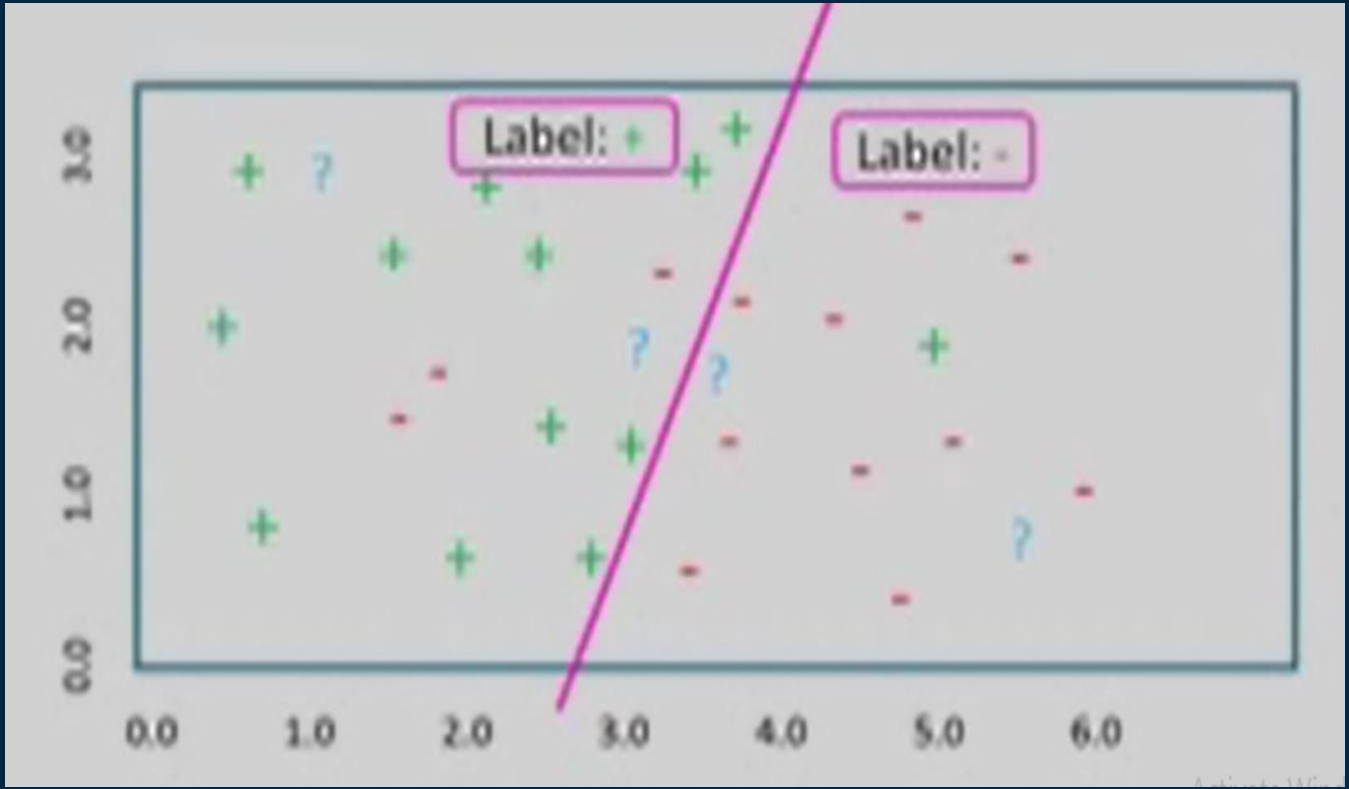

Example:
<0.5,2.8,+>
3.0
2.0
1.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Activate Window

Feature Space

Testing Points ?, ? , ?



Feature Space



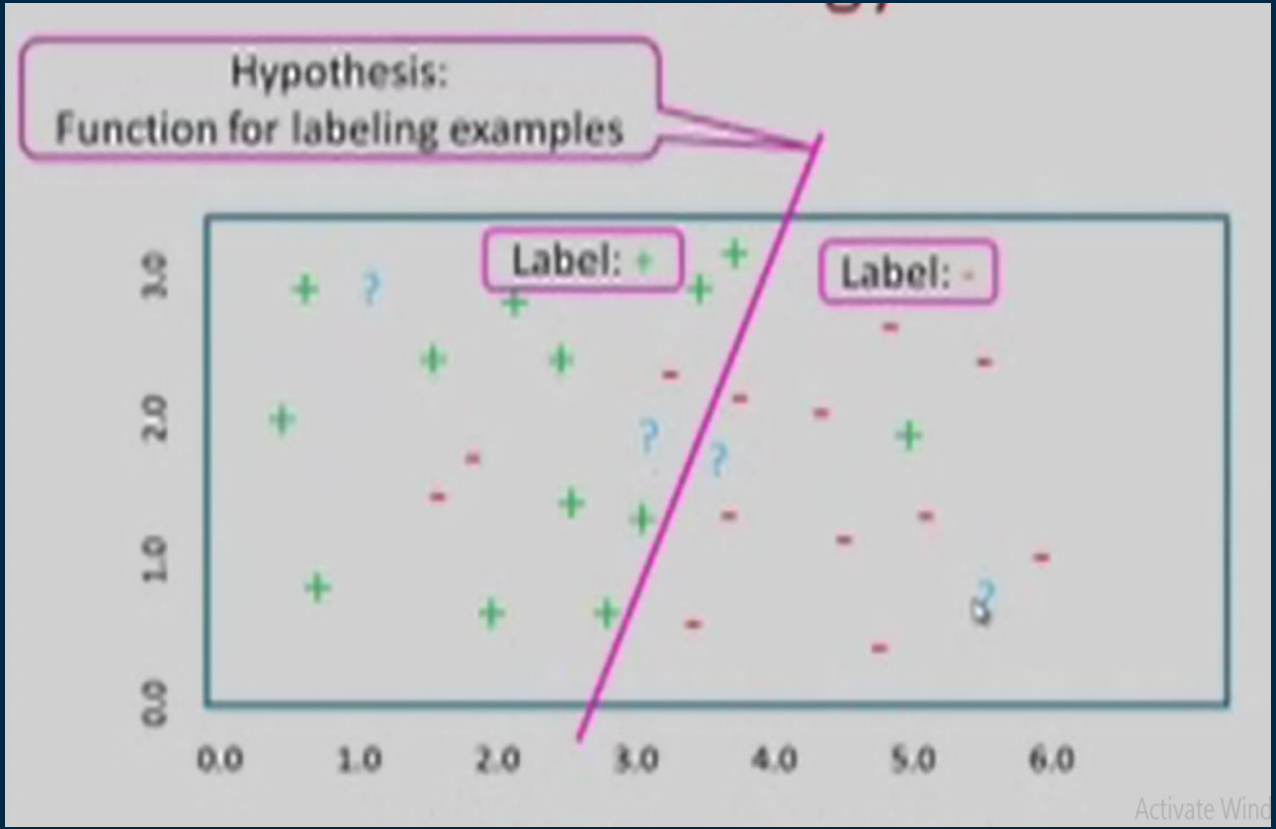
Hypothesis Space

The hypothesis space used by a machine learning system is the set of all legal hypotheses that might possibly be returned by it.
It is typically defined by a Hypothesis, possibly in conjunction with a Bias.

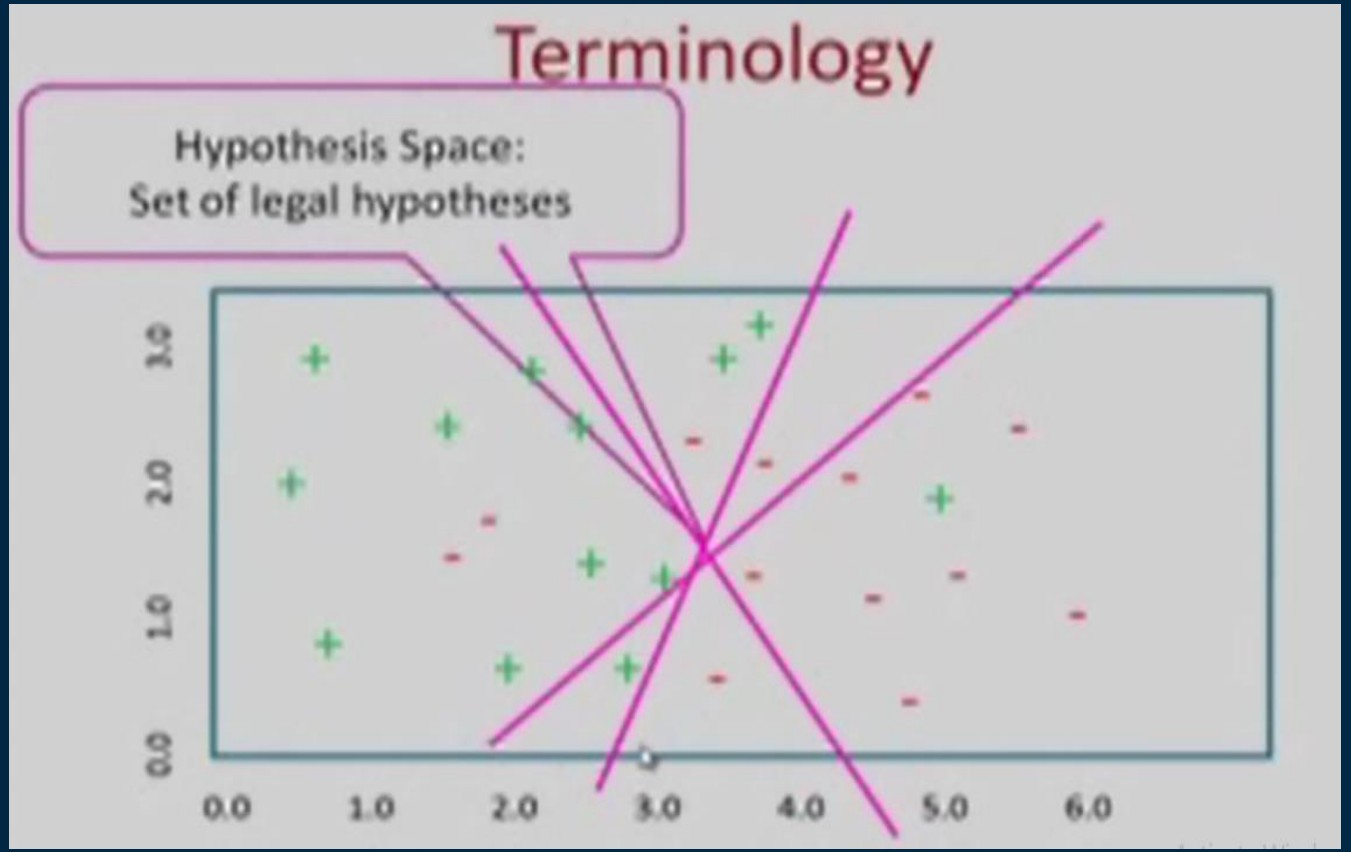
H ⟶ h € H

where, H is a set of Hypothesis
h is o/p of learning algorithms

Feature Space



Feature Space



Hypothesis Space

Terminology

- **Example (x,y):** Instance x with label y=f(x).
- **Training Data S:** Collection of examples observed by learning algorithm.
- **Instance Space X:** Set of all possible objects describable by features.
- **Concept c:** Subset of objects from X (c is unknown).
- **Target Function f:** Maps each instance $x \in X$ to target label $y \in Y$

Hypothesis Space

- If there are 4 (N) input features, there are $2^{16}\left(2^{2^N}\right)$ possible Boolean functions.
- We cannot figure out which one is correct unless we see every possible input-output pair $2^4(2^N)$

Inductive Bias

I**nductive bias** refers to a set of (explicit or implicit) assumptions made by a **learning** algorithm in order to perform induction, that is, to generalize a finite set of observation (training data) into a general model of the domain.

Inductive Bias

- Need to make assumptions
  - Experience alone doesn't allow us to make conclusions about unseen data instances
- Two types of bias:
  - Restriction: Limit the hypothesis space
  - Preference: Impose ordering on hypothesis space

Evaluation and Cross Validation

- To select proper h from a hypothesis space H , for the training data set S,
- we have to evaluate performance algorithm.

- We perform experimental Evaluation by doing
  Error Matrix, Accuracy , Precision / Recall
- Cross Validation is used to split the dataset into training and testing dataset.

Evaluation and Cross Validation

Evaluating predictions

- Suppose we want to make a prediction of a value for a target feature on example **x**:
  - y is the observed value of target feature on example ***x***.
  - $\hat{y}$ is the predicted value of target feature on example ***x***.
  - How is the error measured?

If y == y : No Error, if not then there is an error

Evaluation and Cross Validation

Type of Errors

1. Absolute Errors

$|h(x) - y|$ for Single training experiment

Otherwise

If you have n training experiment set

$$= \frac{1}{n} \in |h(x) - y|$$

2. Sum of squares Errors

$$= \frac{1}{n} \sum_{i=1}^{n} (h(x) - y)^2$$

Note : Both above methods are used to find errors in Regression Problem

Evaluation and Cross Validation

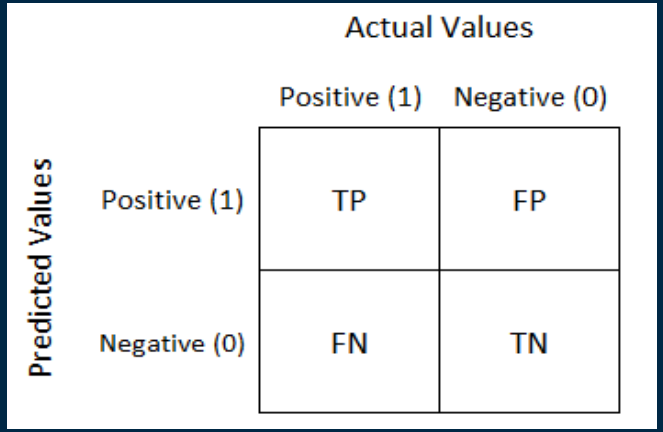
Type of Errors

3. Number of Misclassification

$$= \frac{1}{n} \sum_{i=1}^{n} \delta(h(x), y)$$

Where , δ return 1, if h(x) and y are different and 0 if both are same.

4. Confusion Matrix



Note: Above methods are used to find errors in Classification Problem

Evaluation and Cross Validation

How to Evaluate

True Positive:
Your prediction is positive and its turn out to be true. For example, you had predicted that France would win the world cup, and it won.

True Negative:
When you predicted negative, and it's true. You had predicted that England would not win and it lost.

False Positive:
Your prediction is positive, and it is false.
You had predicted that England would win, but it lost.

False Negative:
Your prediction is negative, and result it is also false.
You had predicted that France would not win, but it won.

Evaluation and Cross Validation

How to Evaluate

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

n = 165	Predicted: No	Predicted: Yes	
Actual: No	Tn =50	FP=10	60
Actual: Yes	Fn=5	Tp=100	105
	55	110	

Precision tells us how many of the correctly predicted cases actually turned out to be positive.

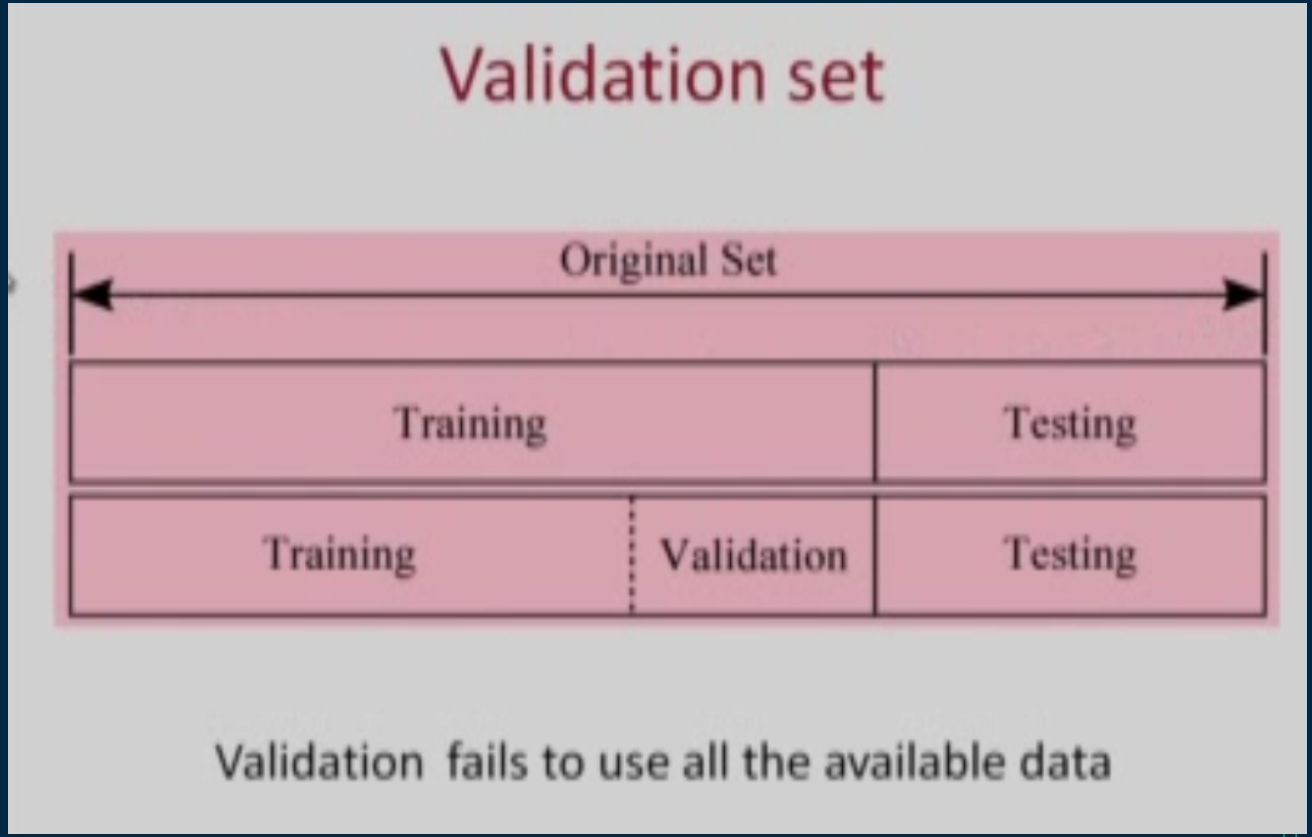
Recall tells us how many of the actual positive cases we were able to predict correctly with our model

$$\text{Precision} = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

$$\text{Recall} = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

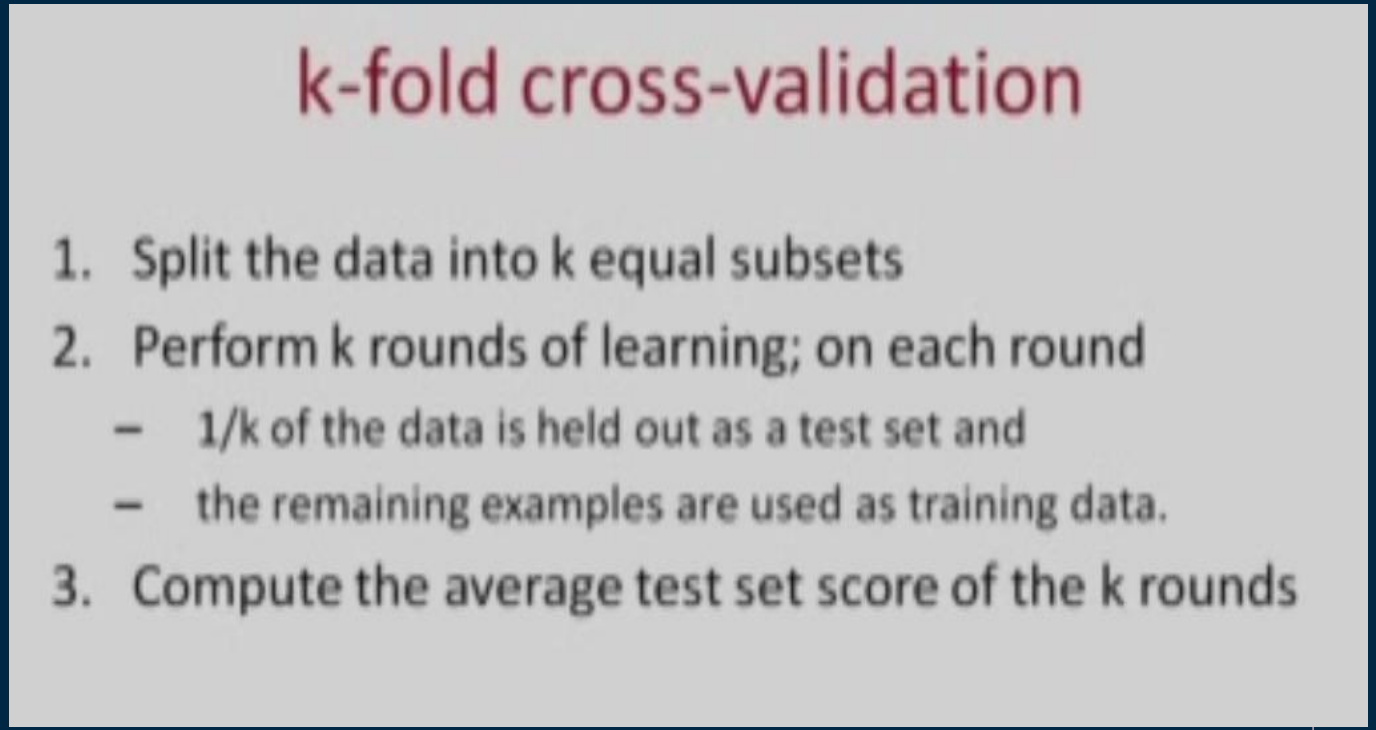
Evaluation and Cross Validation

Cross Validation



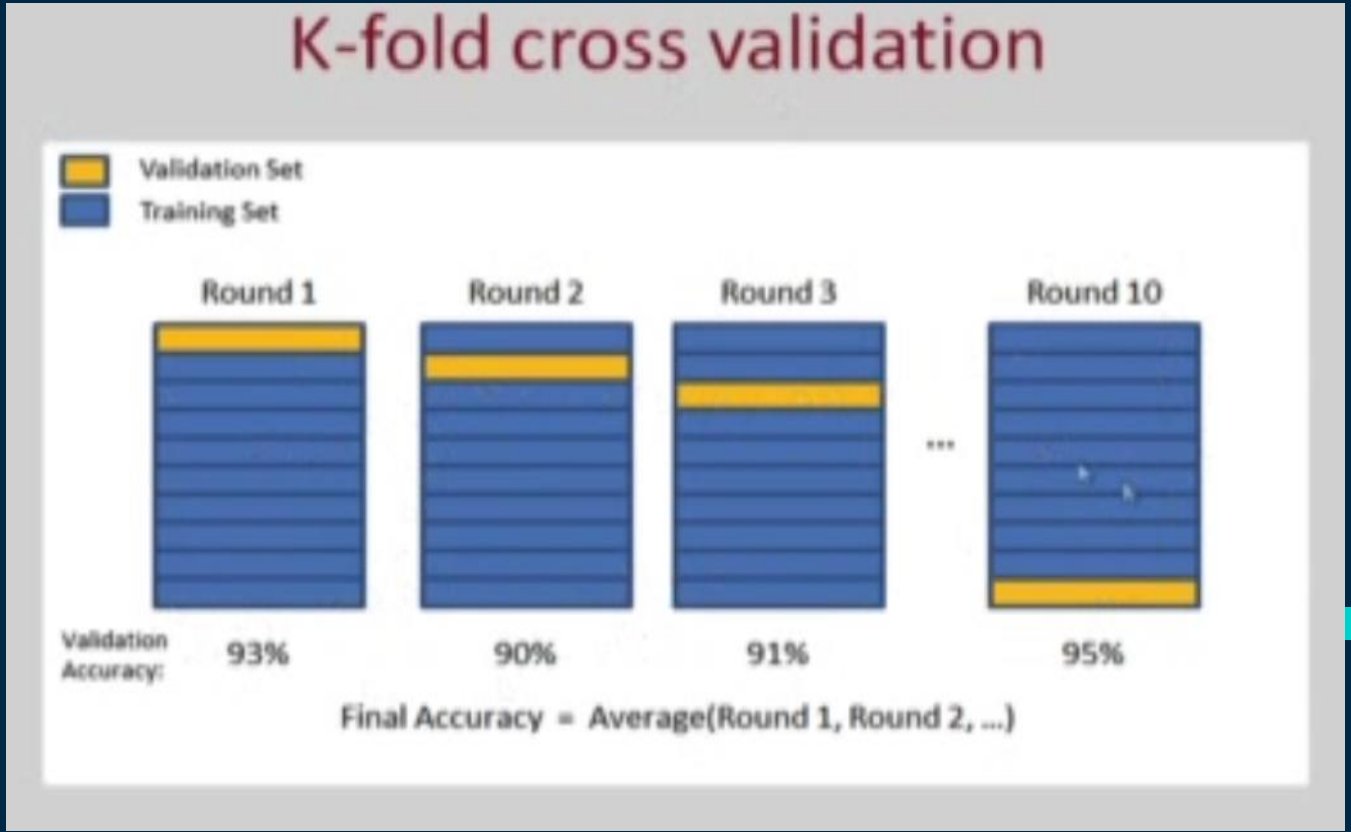
Evaluation and Cross Validation

Cross Validation



Evaluation and Cross Validation

Cross Validation



Thank You