B. Tech. Sem VII
Computer Engineering
Machine Learning

Lecture 1

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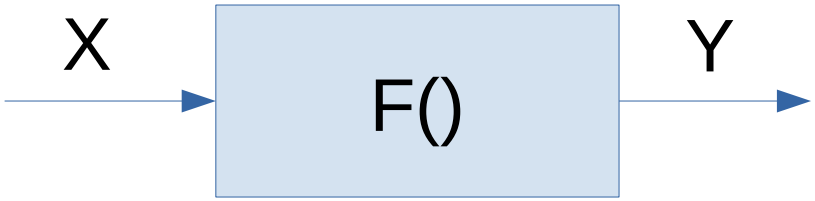
Outline

- Context Setting
- Learning Problem
- What is Machine Learning?
- Types of Learning
- Machine Learning Approaches
- Syllabus and Teaching

Prelude

The kind of problems we discussed and solved so far!!



-The function to convert X into Y is well defined.

* Can be modeled through a formula

Y = Square(X)

* Can be describe through a procedure

Y = Sort (X)

Methods to solve Y = f(X)

Traditional Algorithms : Greedy, Dynamic etc

- Exact solution for some optimization problems are not computable in polynomial time (Hard Problems)

Randomization & Approximation

- When Exact computation is costly, we try to use randomization and/or approximation techniques to find out near optimal solutions.

Can we do better!?

Intelligence & Learning

Intelligence : the ability to acquire and apply knowledge and skills.

→ Should you go out and eat food from a road side eatery today?

Learning : knowledge acquired through study, experience, or being taught.

→ Well, we are participating in the online teaching!! I have prepared slides!!!

Covid-19

Learning New skills

Learning & Intelligence solve Problem

Surprisingly, humans can solve many hard problems so naturally without the need of any complex computing.

→ Recognizing People

→ Recognizing Voice

→ Learning a natural language (English, Gujarati, etc)

Ofcourse, our accuracy at these tasks very based on out intelligence and learning!!

But we keep improving!!!

How to find Y = F(X)?

Artificial Intelligence: (Rules & Reasoning)

Rule based approach: Use hand crafted rules to make the prediction / search for the best solution.

Machine Learning: (Training & Performance)

Data Driven approach : Show data to the machine, and let machine identify the best function/rules to make prediction / search for the best solution.

(BTW… Are we becoming increasing lazy?

Well… not sure… but at least we want the machine to work harder!)

Machine Learning

Arthur Samuel, 1959

- Machine learning explores the study and construction of algorithms that can learn from and make predictions on data
- Programming computers to learn from experience should eventually eliminate the need for much of this detailed programming effort.
- Field of study that gives computers the ability to learn without being explicitly programmed

Applications: email filtering, detection of network intruders, speech recognition, face recognition, games (chess, checkers)

A Problem

Look at the person and identify her first language.

- Input: Profile Picture
- Output: First Language

Can we solve this problem?

If yes,

Which strategy would you use to solve the problem?

Example: Identify the first language of a person from the profile picture

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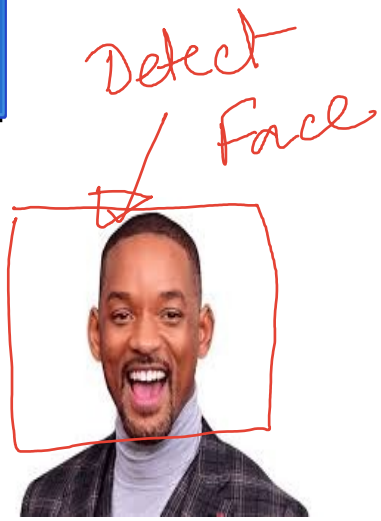
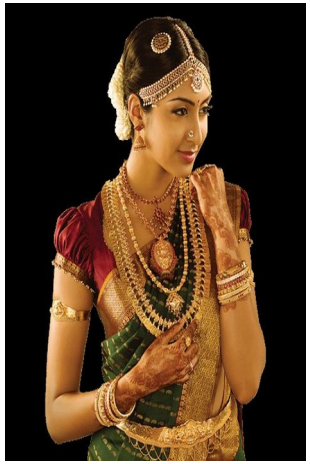
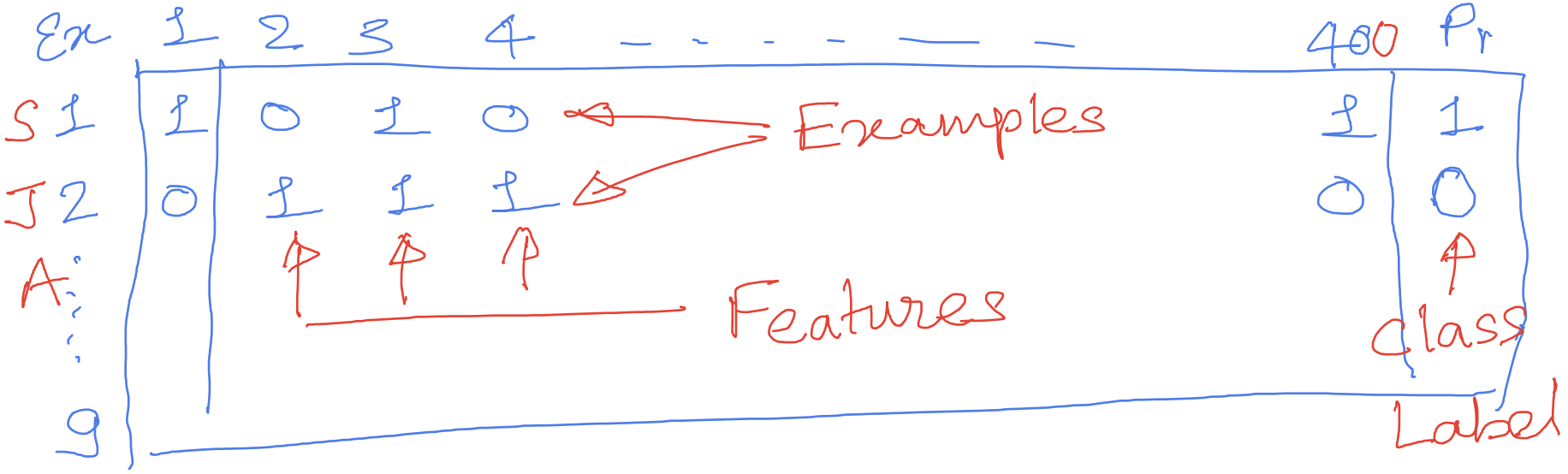




How to identify language from profile pic.

1. Detect face — 20x20
2. Recognize the person — 0/1
3. Find language from person's details.



Features

Turban

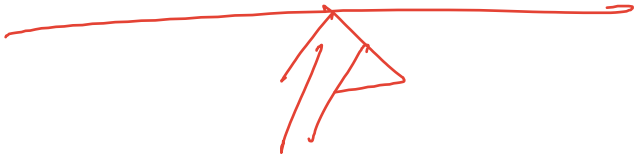
Moustache

Jewellary

Eyes

skin tone

We don't want to work with 20 x 20 features, so we identify some important features



Reduce data size

Well posed learning problem

- A computational program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.
- Example : Hand writing recognition learning problem

  T : Recognize hand written word image

  P : percent of words correctly identified

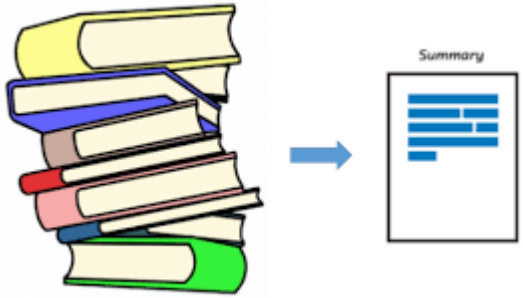
  E : A database of hand written words with given class label
- Q: Define driving vehicle as a learning problem.
- Q: Define chess playing as a learning problem.

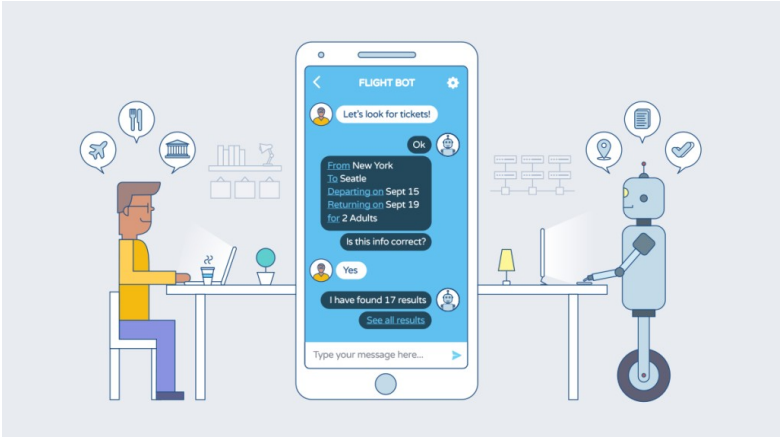
ML Applications(In NLP)

"Welcome to …… Class"

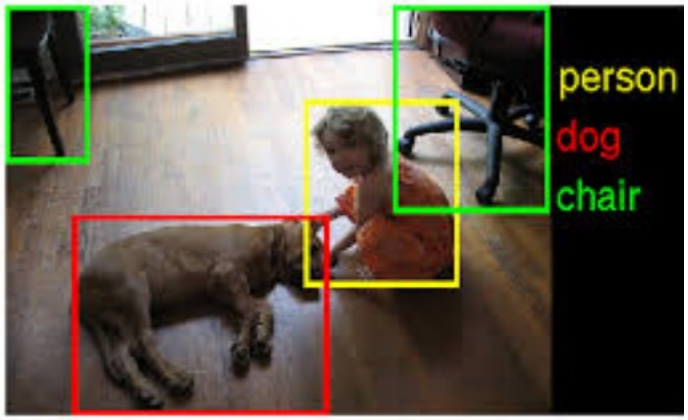
Task 1: Single Supporting Fact

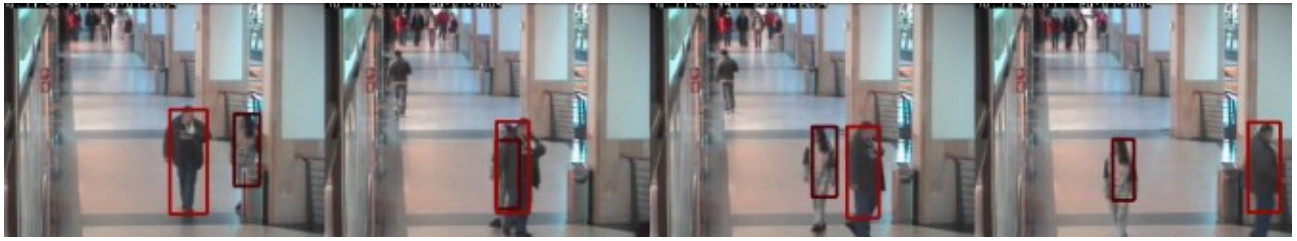
Mary went to the bathroom.
John moved to the hallway.
Mary travelled to the office.
Where is Mary? A:office

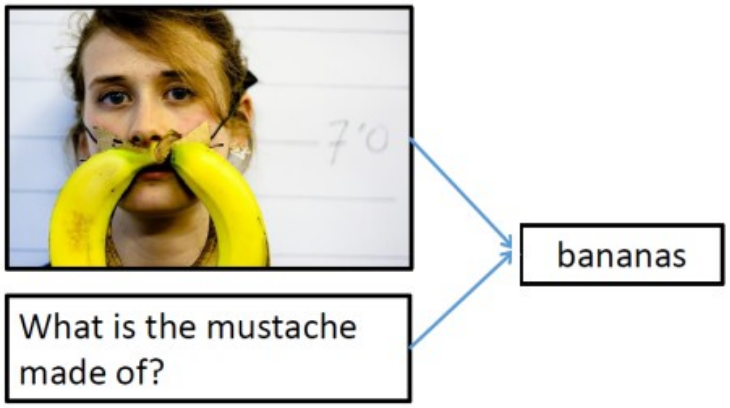




ML Applications (In Visual Processing)







1. Top view of the lights of a city at night, with a well-illuminated square in front of a church in the foreground;

Types of Learning

Supervised learning (Learning with a teacher)

- The machine learning task of learning a function that maps an input to an output based on example input-output pairs.
- Correct output for every training example is already known. (Labeled data)
- Each example is a pair consisting of an input object and a desired output value.

Unsupervised: (Learning from Experience)

- The machine learning task that looks for previously undetected patterns in a data set with no pre-existing labels
- Correct output for every training example is not known (Unlabeled data)

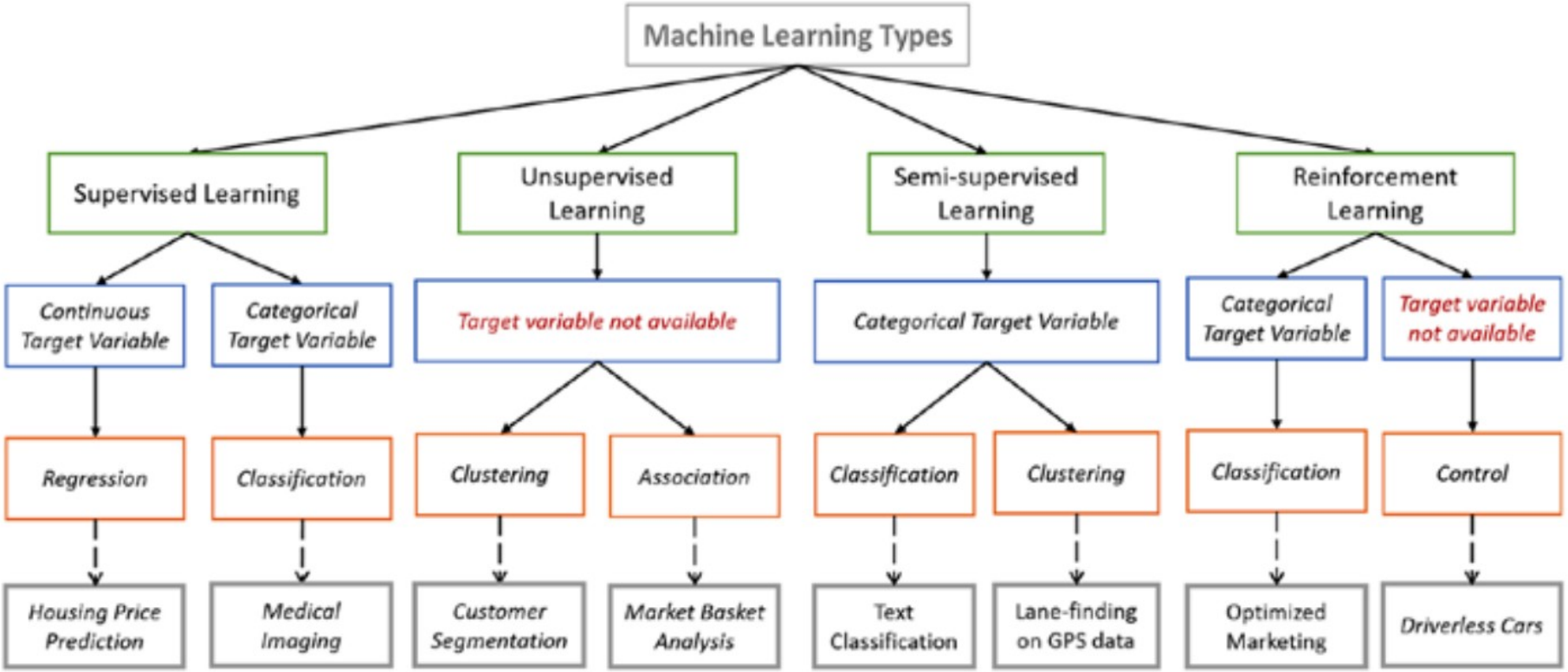
Reinforcement: (Learning from Environment)

of machine learning concerned with how software agents ought to take actions in an environment in order to maximize the notion of cumulative reward.

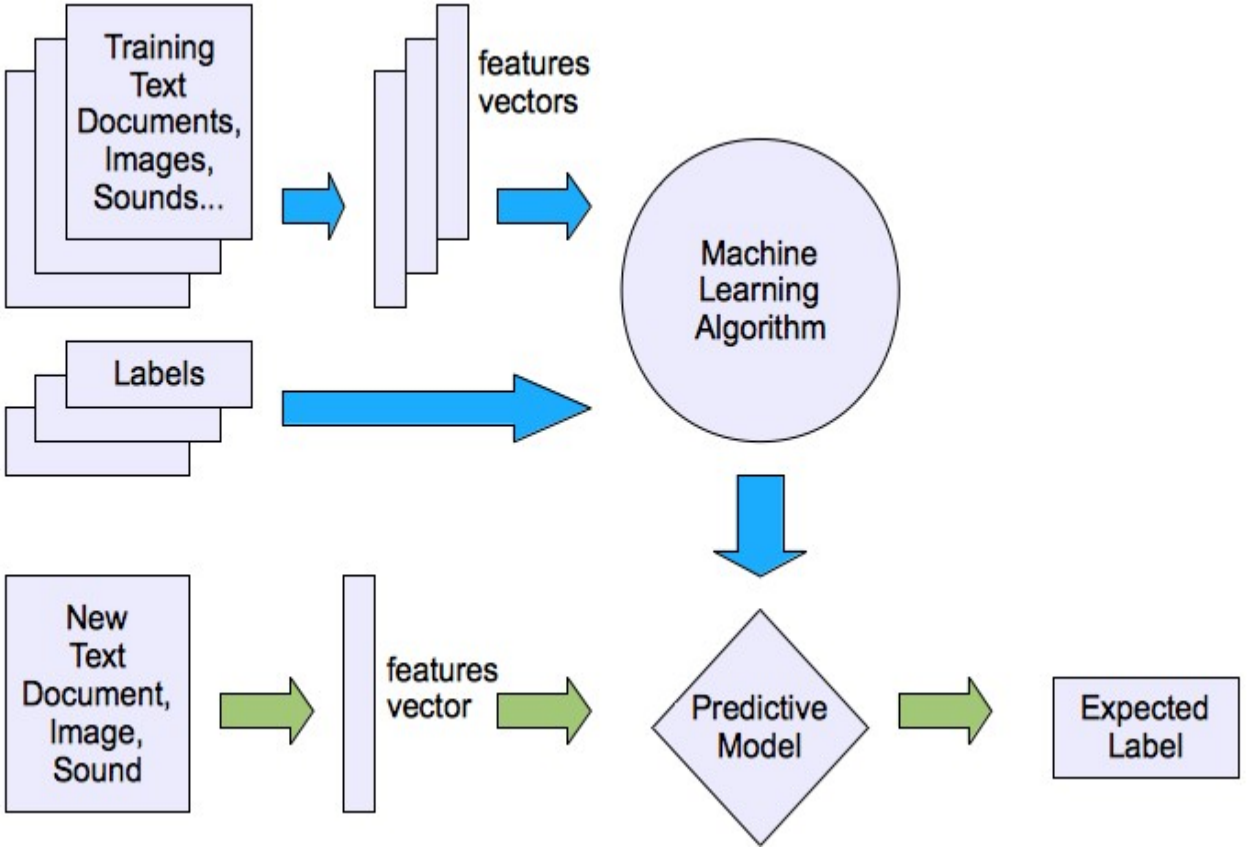
Reinforcement learning differs from supervised learning in not needing labelled input/output pairs be presented

Instead the focus is on finding a balance between exploration (of uncharted territory) and exploitation (of current knowledge).

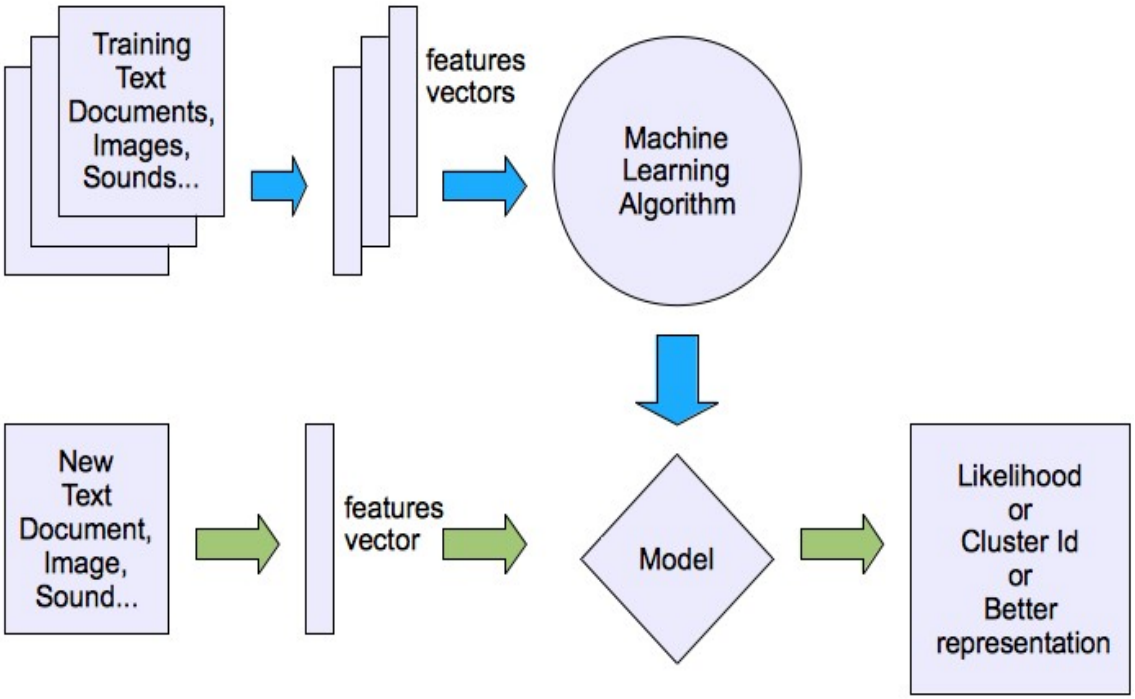
Types of Machine Leaning



Supervised Learning : Classification



Unsupervised Learning : Clustering



Regression

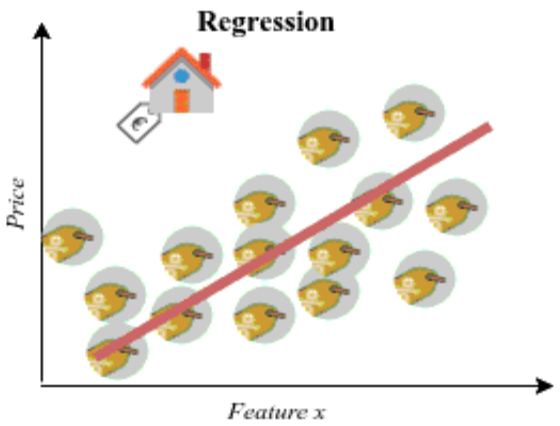
- Supervised Learning
- Output is a continuous quantity
- Main aim is to forecast or predict
- E.g. : Predict stock market price
- Algorithm: Linear Regression

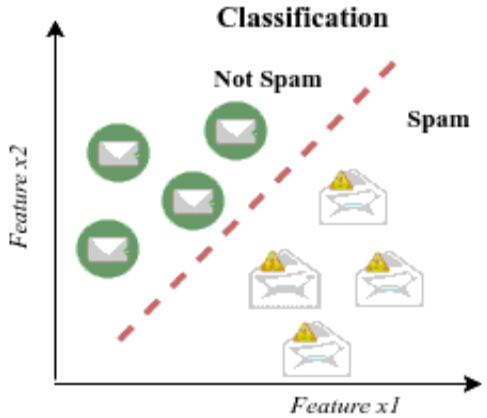
Classification

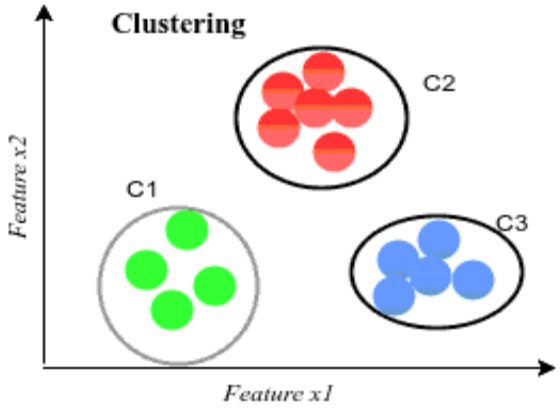
- Supervised Learning
- Output is a categorical quantity
- Main aim is to compute the category of the data
- E.g. : Classify emails as spam or non-spam
- Algorithm: Logistic Regression

Clustering

- Unsupervised Learning
- Assigns data points into clusters
- Main aim is to group similar items clusters
- E.g. : Find all transactions which are fraudulent
- Algorithm: K-means







Prepared by: Prof. Siddharth P. Shah & Prof. Hariom A. Pandya

Syllabus

Introduction: **Overview ,Supervised and unsupervised learning, Learning task, instances, features, labels, reward/loss, training, testing**

Classification: **Overview of classification: setup, training, test, validation dataset, overfitting. Classification families: linear discriminative, non-linear discriminative, decision trees, probabilistic (conditional and generative), nearest neighbor.**

Decision tree classification: **Purity, Gini index, entropy, Algorithms for constructing a decision tree, Pruning methods to avoid over-fitting, Regression trees**

Probabilistic classifiers: **Basics of Probability, Classifiers, LDA, QDA, Generative classifiers: Naive Bayes classification, Conditional classifier: Logistic**

Regression: **Linear regression, Logistic regression**

Hyper Plane Classifier and convex optimization: **Loss regularization framework for classification, loss functions: square, perceptron, logistic, hinge, regularizer. Review of convex optimization and unconstrained function.**

Support Vector Machine: **Max margin motivation: low density, high stability, Margin geometry to primal SVM formulation for separable training data, Dual formulation and role of alpha in a form of sparse local regression, Inseparable data, slack variables, hinge loss, upper bound on 0/1 training loss Handling non-linear regression by lifting data points to higher dimension, Polynomial, Gaussian, RBF kernels, Sequential minimal optimization (SMO) algorithm**

Clustering: **Mixture model and Expectation maximization, K-Means Clustering, Distance based clustering, Density based clustering techniques**

Ensamble learning: **Bagging and Boosting, Random forest, Adaboost**

Dimensionality reduction: **Curse of dimensionality, Principal Component Analysis, Latent Semantic Analysis**

Text Book:

- ***Machine Learning*. T. Mitchell. McGraw-Hill, 1997.**
- ***Understanding Machine Learning*. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017**
- ***Pattern recognition and machine learning* by Christopher Bishop, Springer Verlag, 2006.**

Thank You!