Module 1

CST413 Machine Learning

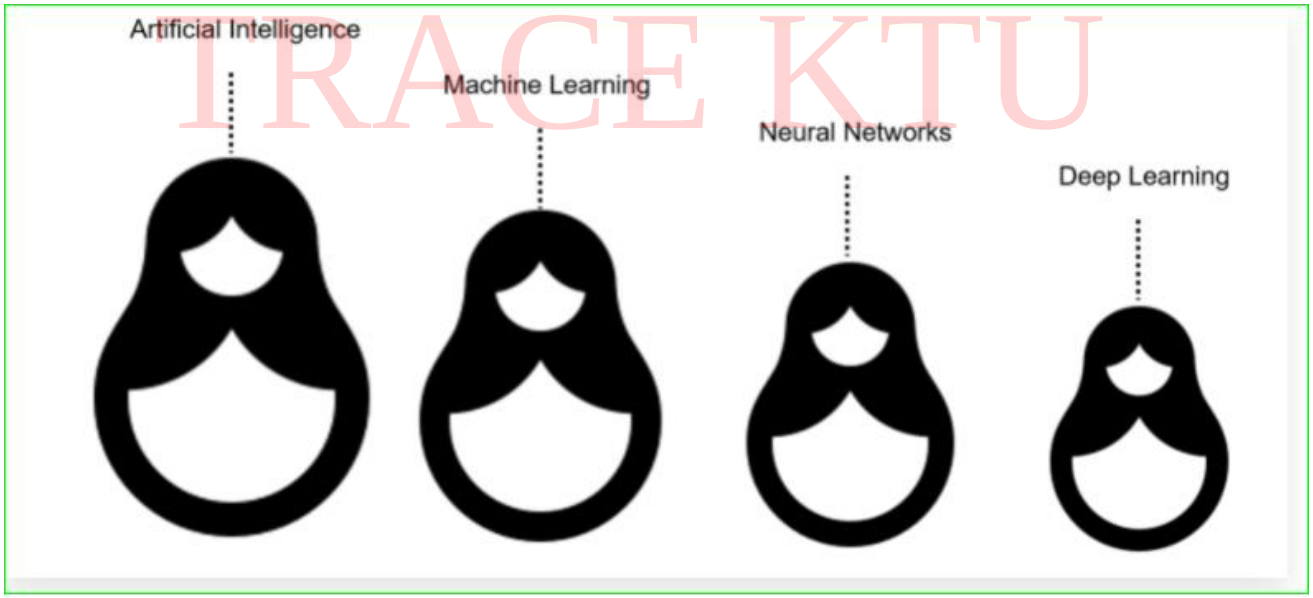
Syllabus

Module-1 (Overview of machine learning)

Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning.

Basics of parameter estimation - maximum likelihood estimation(MLE) and maximum a posteriori estimation(MAP). Introduction to Bayesian formulation.

- Artificial intelligence (AI),ML ,Deep learning, and neural networks represent incredibly exciting and powerful learning-based techniques used to solve many real-world problems.



- Artificial intelligence (AI) is the broadest term used to classify machines that mimic human intelligence.
- It is used to predict, automate, and optimize tasks that humans have historically done, such as speech and facial recognition, decision making, and translation.

What is Machine Learning

▷Machine learning is a subset of artificial intelligence in the field of computer science that often uses statistical techniques to give computers the ability to "learn" (i.e., progressively improve performance on a specific task) with data, without being explicitly programmed.

- Wikipedia

Machine Learning is...

- Machine learning is about predicting the future based on the past.

-- Hal Daume III

What is Machine Learning Cont..

- Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed.
- Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.

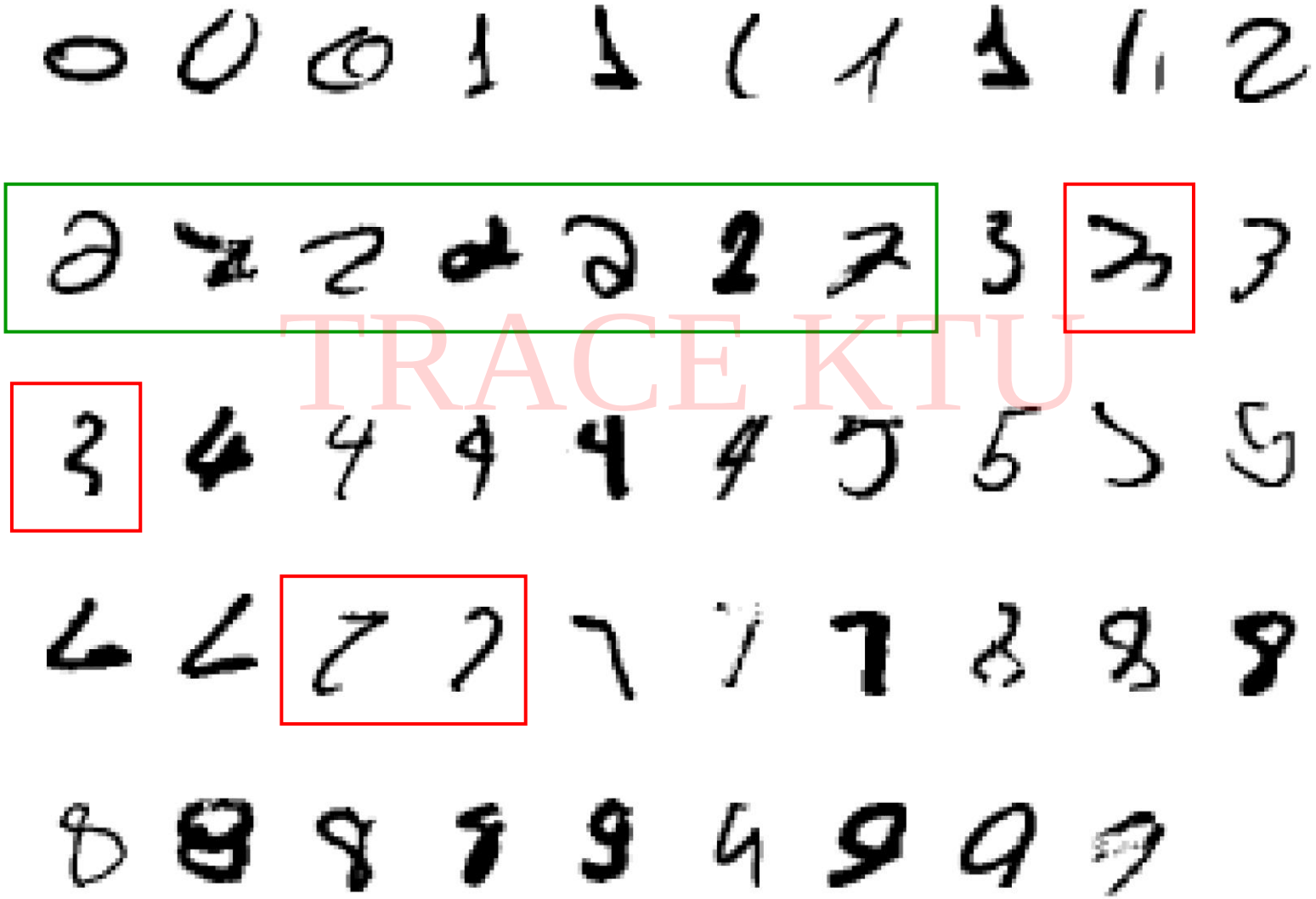
Definition of machine learning

- Arthur Samuel, an early American leader in the field of computer gaming and artificial intelligence, coined the term "Machine Learning" in 1959 while at IBM.
- He defined machine learning as "the field of study that gives computers the ability to learn without being explicitly programmed."
- Different authors define the term differently. We give below two more definitions.
  - Machine learning is programming computers to optimize a performance criterion using example data or past experience.
    - We have a model defined up to some parameters, and learning is the execution of a computer program to optimize the parameters of the model using the training data or past experience.
    - The model may be predictive to make predictions in the future, or descriptive to gain knowledge from data, or both.
  - The field of study known as machine learning is concerned with the question of how to construct computer programs that automatically improve with experience.

Why “Learn” ?

- There is no need to “learn” to calculate payroll
- 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)

A classic example of a task that requires machine learning: It is very hard to say what makes a 2



Slide credit: Geoffrey Hinton

Definition of learning

- Definition:
  - A computer 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 T, as measured by P, improves with experience E.

- Definition:
  - A computer program which learns from experience is called a machine learning program or simply a learning program.
  - Such a program is sometimes also referred to as a learner.

▷ Examples:

i) Handwriting recognition learning problem

- Task T: Recognising and classifying handwritten words within images
- Performance P: Percent of words correctly classified
- Training experience E: A dataset of handwritten words with given classifications

ii) A robot driving learning problem

- Task T: Driving on highways using vision sensors
- Performance measure P: Average distance traveled before an error
- Training experience: A sequence of images and steering commands recorded while observing a human driver.

What We Talk About, When We Talk About "Learning"

- Learning general models from a data of particular examples .
- Data is cheap and abundant (data warehouses, data marts); knowledge is expensive and scarce.
- Build a model that is a **good and useful approximation** to the data.
- Machine learning uses various algorithms for building mathematical models and making predictions using historical data or information.
- Currently, it is being used for various tasks such as image recognition, speech recognition, email filtering, Facebook auto-tagging, recommender system, and many more.

How machines learn

- Basic components of learning process:
  - The learning process, whether by a human or a machine, can be divided into four components, namely, data storage, abstraction, generalization and evaluation.
  - Figure 1.1 illustrates the various components and the steps involved in the learning process

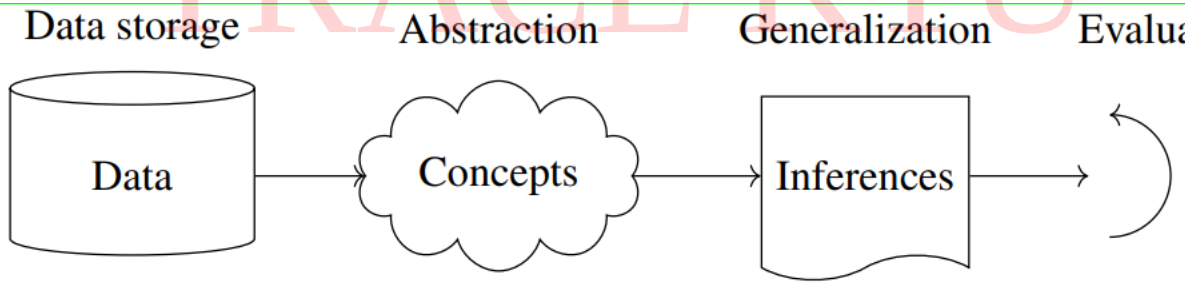


Figure 1.1: Components of learning process

- Data storage:
  - Facilities for storing and retrieving huge amounts of data are an important component of the learning process.
  - Humans and computers alike utilize data storage as a foundation for advanced reasoning.

  - In a human being, the data is stored in the brain and data is retrieved using electrochemical signals.

  - Computers use hard disk drives, flash memory, random access memory and similar devices to store data and use cables and other technology to retrieve data.

Abstraction:

- The second component of the learning process is known as abstraction. Abstraction is the process of extracting knowledge about stored data.
- This involves creating general concepts about the data as a whole.

- The creation of knowledge involves application of known models and creation of new models.
- *The process of fitting a model to a dataset is known as training.*
- When the model has been trained, the data is transformed into an abstract form that summarizes the original information.

- Generalization :
  - The third component of the learning process is known as generalisation.
  - The term generalization describes the process of turning the knowledge about stored data into a form that can be utilized for future action.
  - These actions are to be carried out on tasks that are similar, but not identical, to those what have been seen before.
  - In generalization, the goal is to discover those properties of the data that will be most relevant to future tasks.

- Evaluation :
  - Evaluation is the last component of the learning process.
  - It is the process of giving feedback to the user to measure the utility of the learned knowledge.
  - This feedback is then utilised to effect improvements in the whole learning process.

Applications of machine learning

- Application of machine learning methods to large databases is called data mining.
- In data mining, a large volume of data is processed to construct a simple model with valuable use, for example, having high predictive accuracy. The following is a list of some of the typical applications of machine learning.
  1. In retail business, machine learning is used to study consumer behaviour. Eg: Market basket analysis, Customer relationship management (CRM)
  2. In finance, banks analyze their past data to build models to use in credit applications, fraud detection, and the stock market.
  3. In manufacturing, learning models are used for optimization, control, and troubleshooting.
  4. In medicine, learning programs are used for medical diagnosis.
  5. In telecommunications, call patterns are analyzed for network optimization and maximizing the quality of service.

6. In science, large amounts of data in physics, astronomy, and biology can only be analyzed fast enough by computers.
7. In artificial intelligence, it is used to teach a system to learn and adapt to changes so that the system designer need not foresee and provide solutions for all possible situations.
8. It is used to find solutions to many problems in vision, speech recognition, and robotics.
9. Machine learning methods are applied in the design of computer-controlled vehicles to steer correctly when driving on a variety of roads.
10. Machine learning methods have been used to develop programmes for playing games such as chess, backgammon ..
11. **Web mining**: Search engines

Understanding data

- An important component of the machine learning process is data storage,
- The different types and forms of data that are encountered in the machine learning process.
- Unit of observation
  - By a unit of observation ,mean the smallest entity with measured properties of interest for a study.
- Examples
  - • A person, an object or a thing
  - • A time point
  - • A geographic region
  - • A measurement

- Examples and features :
  - Datasets that store the units of observation and their properties can be imagined as collections of data consisting of the following:
  - Examples: An “example” is an instance of the unit of observation for which properties have been recorded.
  - An “example” is also referred to as an “instance”, or “case” or “record.”
  - • Features: A “feature” is a recorded property or a characteristic of examples. It is also referred to as “attribute”, or “variable” or “feature.”

Examples for “examples” and “features”

- 1. Cancer detection:
  - Consider the problem of developing an algorithm for detecting cancer.
  - (a) The units of observation are the patients.
  - (b) The examples are members of a sample of cancer patients.
  - (c) The following attributes of the patients may be chosen as the features:
    - • gender • age • blood pressure • the findings of the pathology report after a biopsy

- Pet selection:
  - Suppose we want to predict the type of pet a person will choose.

(a) The units are the persons.

(b) The examples are members of a sample of persons who own pets

(c) The features might include age, home region, family income, etc. of persons who own pets.

Different forms of data

- 1. Numeric data:
  - If a feature represents a characteristic measured in numbers, it is called a numeric feature.
- 2. Categorical or nominal:
  - A categorical feature is an attribute that can take on one of a limited, and usually fixed, number of possible values on the basis of some qualitative property. A categorical feature is also called a nominal feature.eg:model-SEL,SE,SES
- 3. Ordinal data :
  - This denotes a nominal variable with categories falling in an ordered list.
  - Examples include clothing sizes such as small, medium, and large, or a measurement of customer satisfaction on a scale from “not at all happy” to “very happy.”

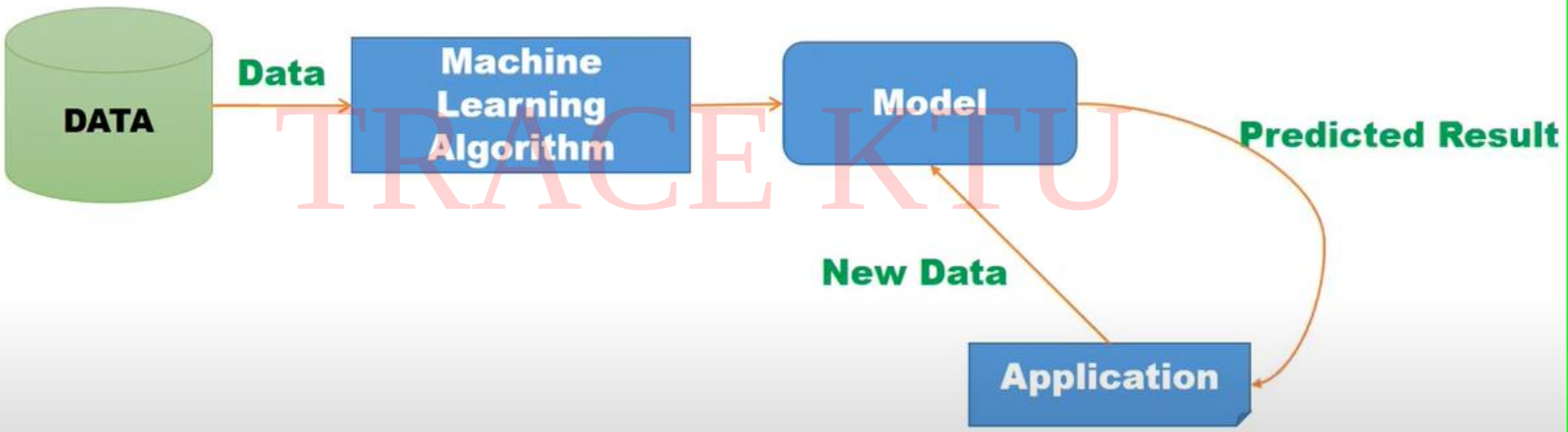
features

year	model	price	mileage	color	transmission
2011	SEL	21992	7413	Yellow	AUTO
2011	SEL	20995	10926	Gray	AUTO
2011	SEL	19995	7351	Silver	AUTO
2011	SEL	17809	11613	Gray	AUTO
2012	SE	17500	8367	White	MANUAL
2010	SEL	17495	25125	Silver	AUTO
2011	SEL	17000	27393	Blue	AUTO
2010	SEL	16995	21026	Silver	AUTO
2011	SES	16995	32655	Silver	AUTO

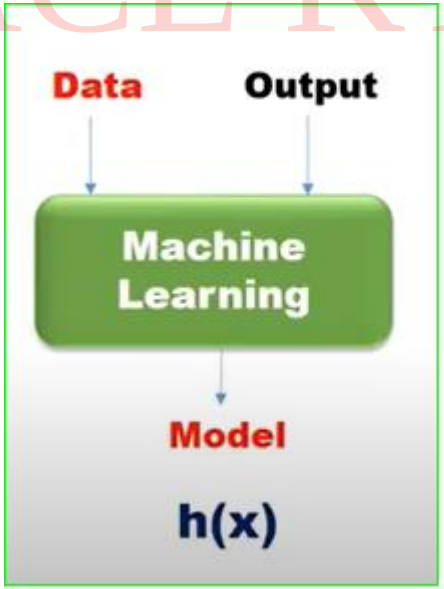
examples

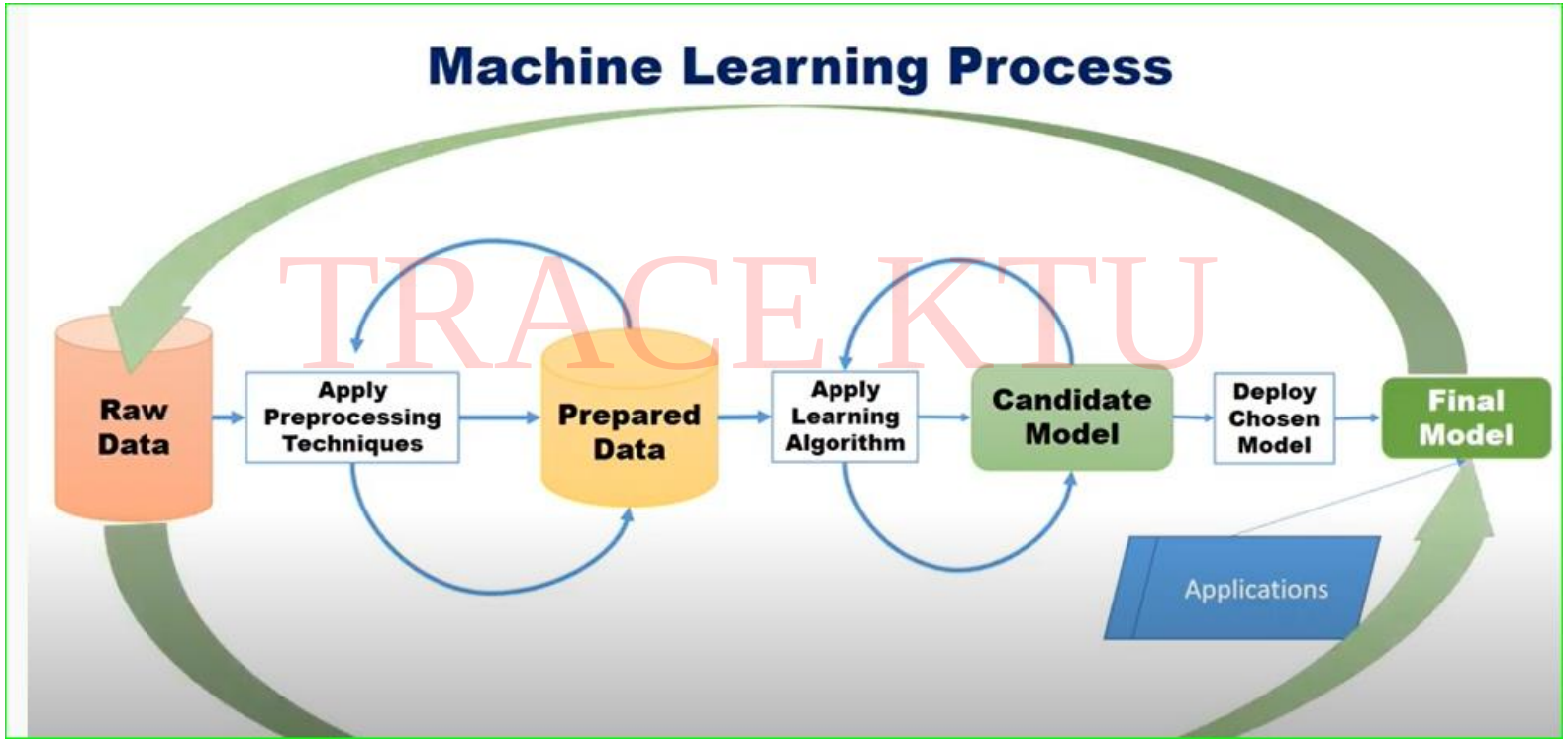
ıre 1.2: Example for "examples" and "features" collected in a matrix format (data relates to ›mobiles and their features)

MACHINE LEARNING : GENERAL OVERVIEW



Traditional Programming vs Machine Learning




Machine Learning Process
Raw Data
Apply Preprocessing Techniques
Prepared Data
Apply Learning Algorithm
Candidate Model
Deploy Chosen Model
Final Model
Applications

Kinds of Machine Learning

- Supervised Learning
  - Classification (Logistic Regression, SVM, Naïve bayes, Decision Trees,)
  - Regression (Linear regression, multi variate regression, polynomial regression)
  - Association learning
- Unsupervised Learning
- Reinforcement Learning

Supervised Learning

- A majority of practical machine learning uses supervised learning.

- In supervised learning, the system tries to learn from the previous examples that are given.
- Supervised learning is the machine learning task of learning a function that maps an input to an output based on example input-output pairs.(training data)

Supervised Learning

- Train the machine using data which is well labeled
- A machine is provided with new set of examples(data)
- supervised learning algorithm analyses the training data(set of training examples) and produces an correct outcome from labeled data.

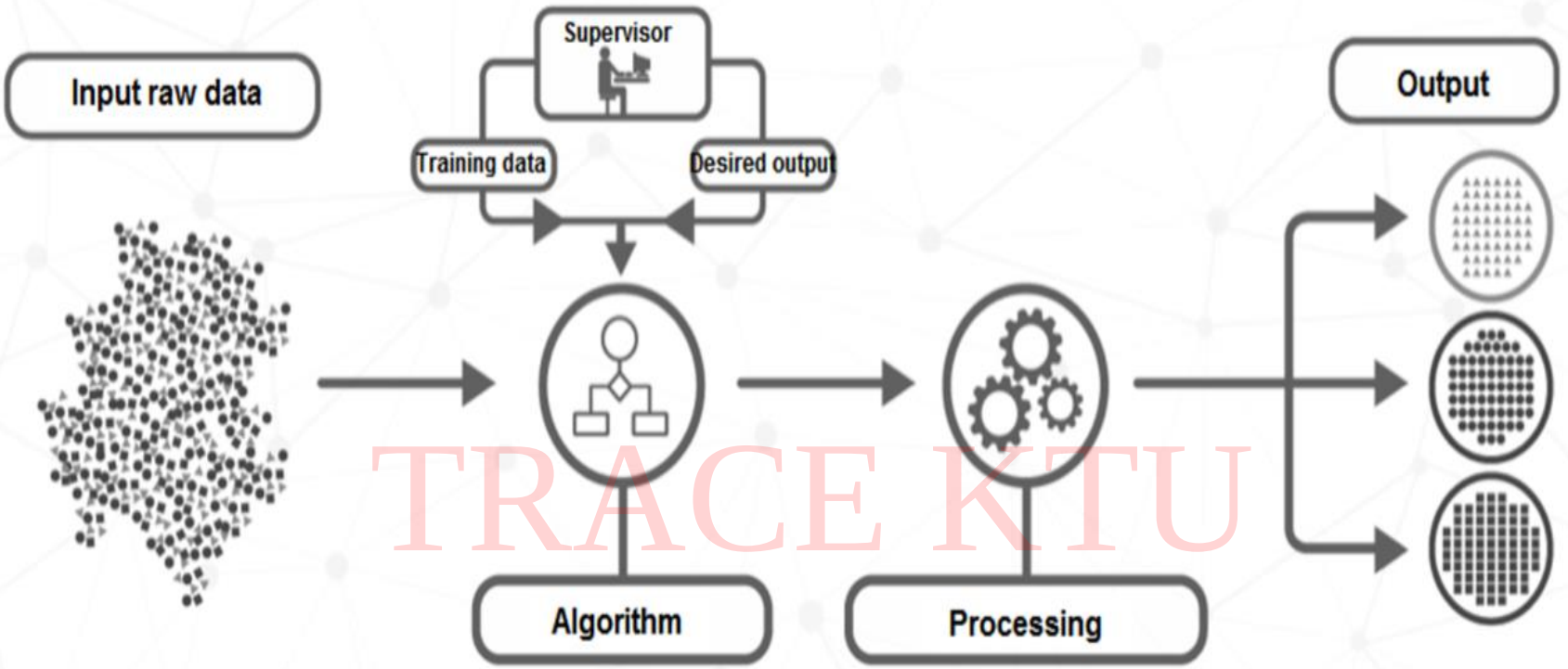


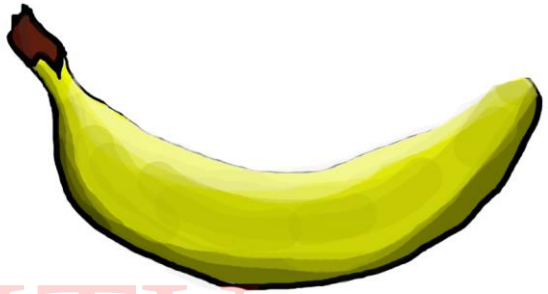
Figure 1.4: Supervised learning

- Consider the following data regarding patients entering a clinic. The data consists of the gender and age of the patients and each patient is labeled as “healthy” or “sick”.

gender	age	label
M	48	sick
M	67	sick
F	53	healthy
M	49	healthy
F	34	sick
M	21	healthy

Based on this data, when a new patient enters the clinic, how can one predict whether he/she is healthy or sick?

Supervised Learning



- If shape of object is rounded and depression at top having color Red then it will be labelled as –**Apple**.
- If shape of object is long curving cylinder having color Green-Yellow then it will be labelled as –Banana.

Apple

Apple

Orange

Apple

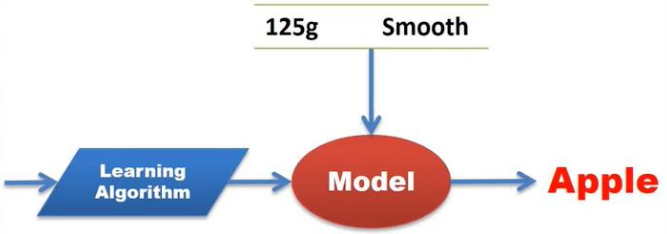
Orange

Orange

Apple

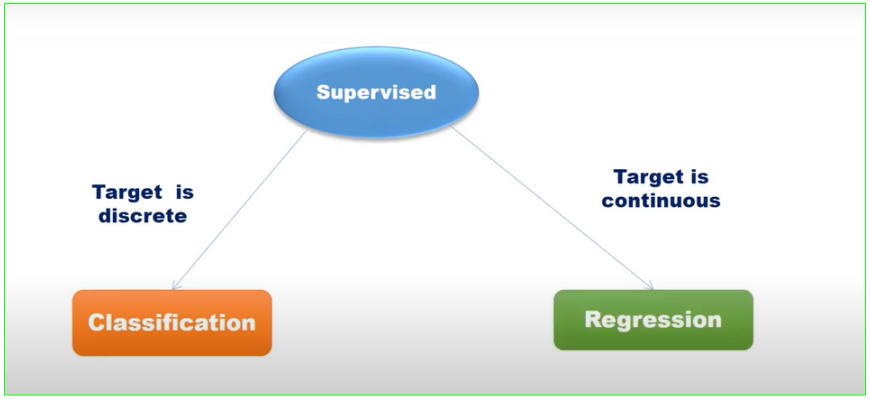
Orange

Weight	Texture	Fruit
140g	Smooth	Apple
130g	Smooth	Apple
150g	Rough	Orange
135	Smooth	Apple
170g	Rough	Orange
180g	Rough	Orange
110g	Smooth	Apple
155g	Rough	Orange



Supervised Learning

- Supervised learning classified into two categories of algorithms:
  - **Classification**: A classification problem is when the output variable is a category, such as “Red” or “blue” or “disease” and “no disease”.(sunny,rainy),
  - **Regression**: A regression problem is when the output variable is a real value, such as “dollars” or “weight”.



Examples of Regression

Predict the amount of rainfall

Estimate the demand for a product

Stock Price Prediction

Predicting actual price of

- Define supervised learning? Name special cases of supervised learning depending on whether the inputs/outputs are categorical, or continuous

GENERAL CLASSES OF MACHINE LEARNING PROBLEMS

- Types of Supervised Learning
- Classification
  - The problem of identifying to which of a set of categories a new observation belongs, based on a training set of data containing observations (or instances) whose category membership is known.
  - Image belongs to cat /Dog

Classification

Score1	29	22	10	31	17	33	32	20
Score2	43	29	47	55	18	54	40	41
Result	Pass	Fail	Fail	Pass	Fail	Pass	Pass	Pass

- If we have some new data, say "Score1 = 25" and "Score2 = 36", what value should be assigned to "Result" corresponding to the new data?

- Discriminant:

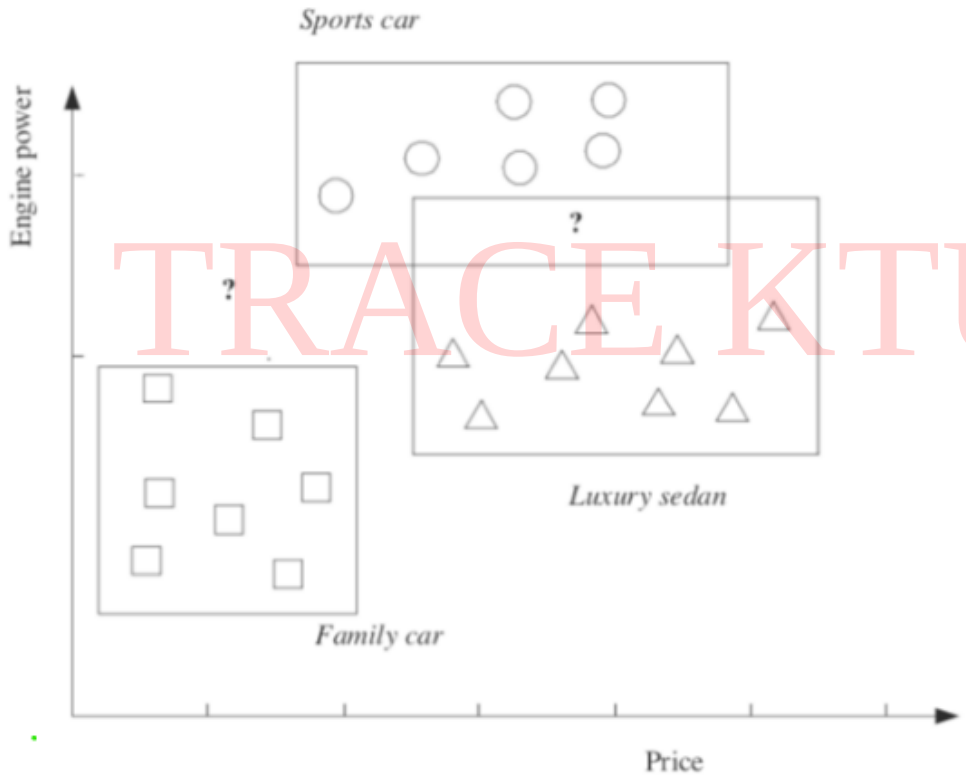
  - A discriminant of a classification problem is a rule or a function that is used to assign labels to new observations.
  - Examples i) Consider the data given and the associated classification problem.
  - We may consider the following rules for the classification of the new data:
  - IF Score1 + Score2 ≥ 60, THEN “Pass” ELSE “Fail”.
  - IF Score1 ≥ 20 AND Score2 ≥ 40 THEN “Pass” ELSE “Fail”

Classification

- There are several machine-learning algorithms for classification. The following are some of the well-known algorithms.
  - Logistic regression
  - Naive Bayes algorithm
  - k-NN algorithm
  - Decision tree algorithm
  - Support vector machine algorithm
  - Random forest algorithm

  - Examples:
  - Remarks
    - A classification problem requires that examples be classified into one of two or more classes.
    - classification can have real-valued or discrete input variables.
    - A problem with two classes is often called a two-class or binary classification problem.
    - A problem with more than two classes is often called a multi-class classification problem.

Multi Class Classification



Multi Class Classification

- In general we can have K classes denoted as Ci , i = 1, . . . , K, and an input instance belongs to one and exactly one of them.
- Example: here there are three classes: family car, sports car, and luxury sedan.
- There are three hypotheses induced, each one covering the instances of one class and leaving outside the instances of the other two classes.
- '?' are reject regions where no, or more than one, class is chosen
- Aim of K Class classification ;is to learn the boundary separating the instances of one class from the instances of all other classes.
- We view a K-class classification problem as K two-class problems

Examples of Binary Classification Problems

s this email spam or ham { spam , ham}

Will the customer buy this product { yes , no}

Will it rain tomorrow { yes,no}

Classify tumor as benign or malignant{ benign, malignant}

Examples of Multiclass Problems

Is this review positive , neutral or negative ? { positive, neutral, negative}

Determine if loan application is high , medium or low-risk {high, medium,low}

Is this movie a romantic, comedy, documentary, or thriller? {romantic, comedy, documentary, thriller}

Which category of products is most interesting to this customer?“ { furniture , kitchen , books , food etc.}

Regression

- the problem of predicting the value of a numeric variable based on observed values of the variable.
- The value of the output variable-number such as integer,floating point value.

Price (US$)	Age (years)	Distance (KM)	Weight (pounds)
13500	23	46986	1165
13750	23	72937	1165
13950	24	41711	1165
14950	26	48000	1165
13750	30	38500	1170
12950	32	61000	1170
16900	27	94612	1245
18600	30	75889	1245
21500	27	19700	1185
12950	23	71138	1105

Suppose we are required to estimate the price of a car aged 25 years with distance 53240 KM and weight 1200 pounds.

Regression

- Let x denote the set of input variables and y the output variable.
- In machine learning, the general approach to regression is to assume a model, that is, some mathematical relation between x and y, involving some parameters say, θ, in the following form:

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

- The function f(x, θ) is called the regression function.
- Let X denote the car attributes and Y be the price of the car.
- The machine learning algorithm optimizes the parameters in the set θ such that the approximation error is minimized our estimates are as close as possible to the correct values given in the training set.

Different Regression models:

- There are various types of regression techniques available to make predictions.
  - **Simple linear regression**: There is only one continuous independent variable x and the assumed relation between the independent variable and the dependent variable y is
    $$y = a + bx.$$
  - **Multivariate linear regression**: There are more than one independent variable, say x1, . . . , xn, and the assumed relation between the independent variables and the dependent variable is
    $$y = a0 + a1x1 + \cdots + an\ xn.$$
  - **Polynomial regression**: There is only one continuous independent variable x and the assumed model is
    $$y = a0 + a1x + \cdots + anx^n$$
  - The assumed model involves certain probability distributions.

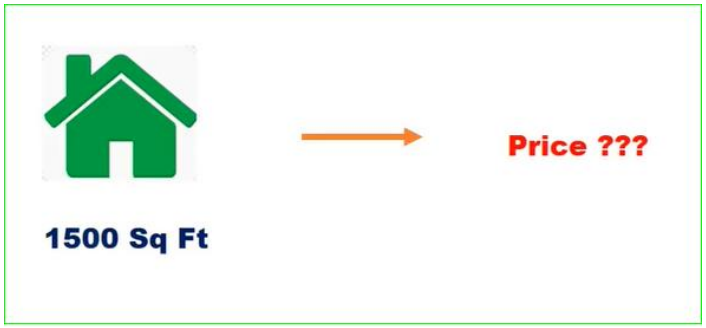
Regression

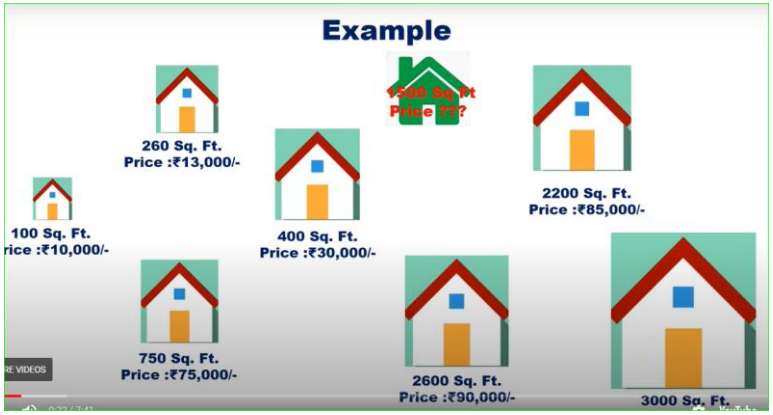
For example, if the input variables are “Age”, “Distance” and “Weight” and the output variable is “Price”, the model may be

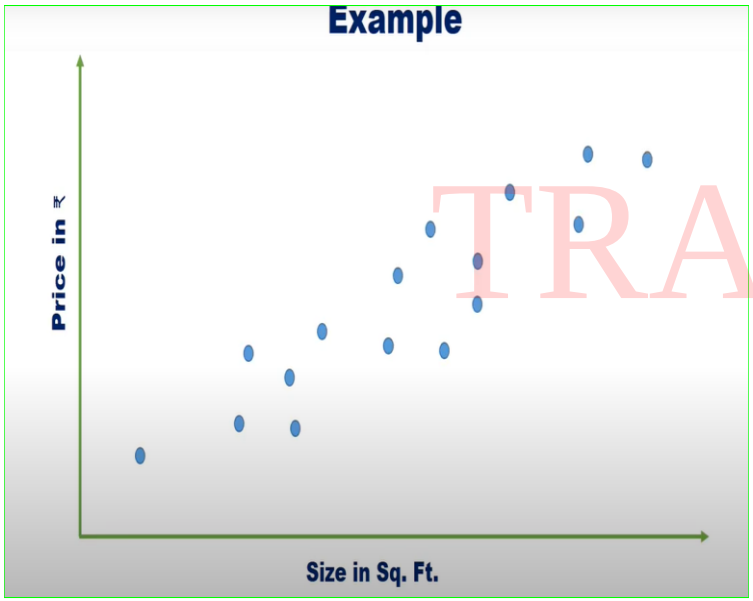
$$y = f(x,\theta)$$

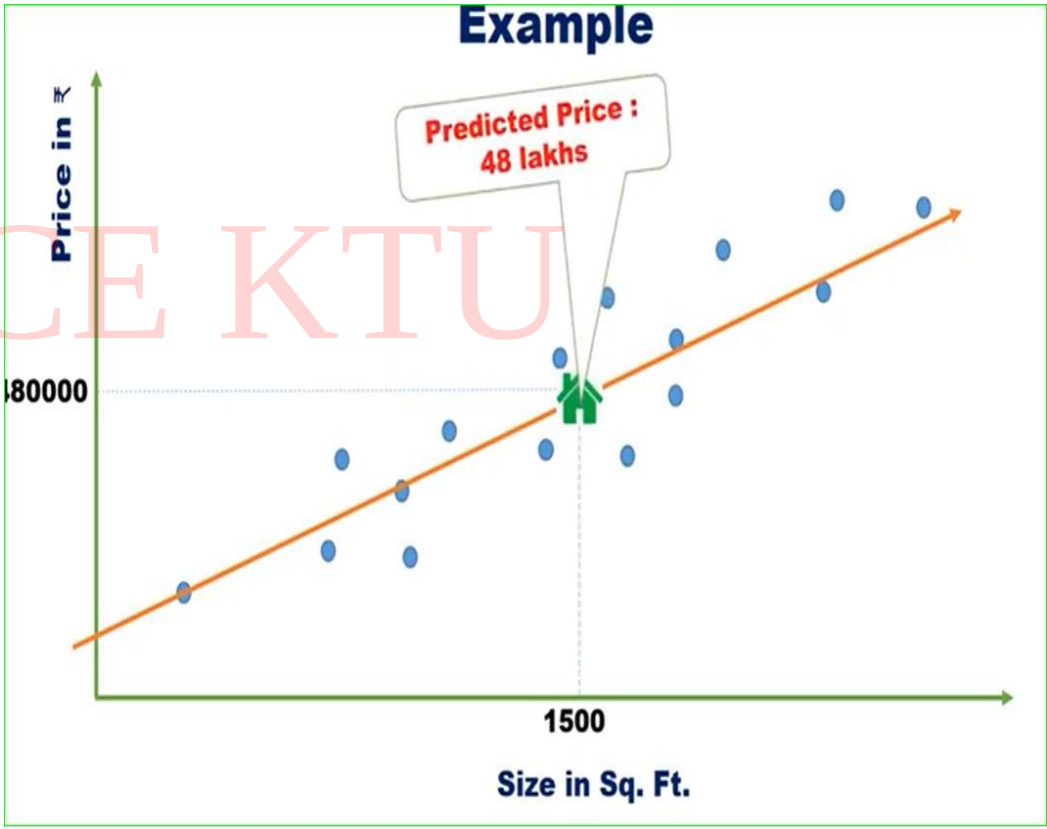
$$\text{Price} = a_0 + a_1 \times (\text{Age}) + a_2 \times (\text{Distance}) + a_3 \times (\text{Weight})$$

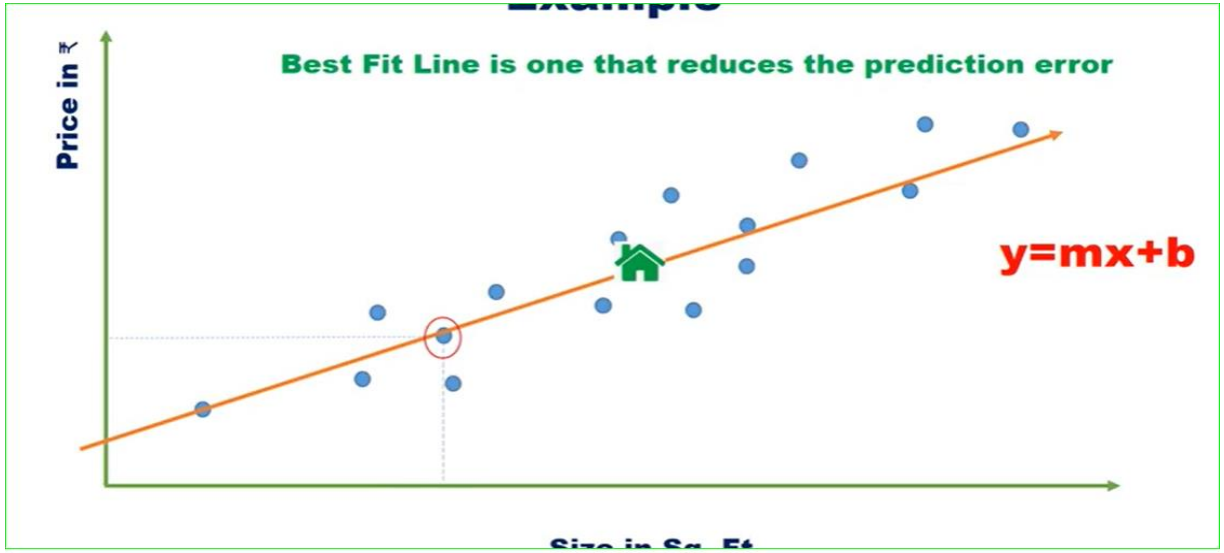
where x = (Age, Distance, Weight) denotes the set of input variables and $\theta = (a_0, a_1, a_2, a_3)$ denotes the set of parameters of the model.

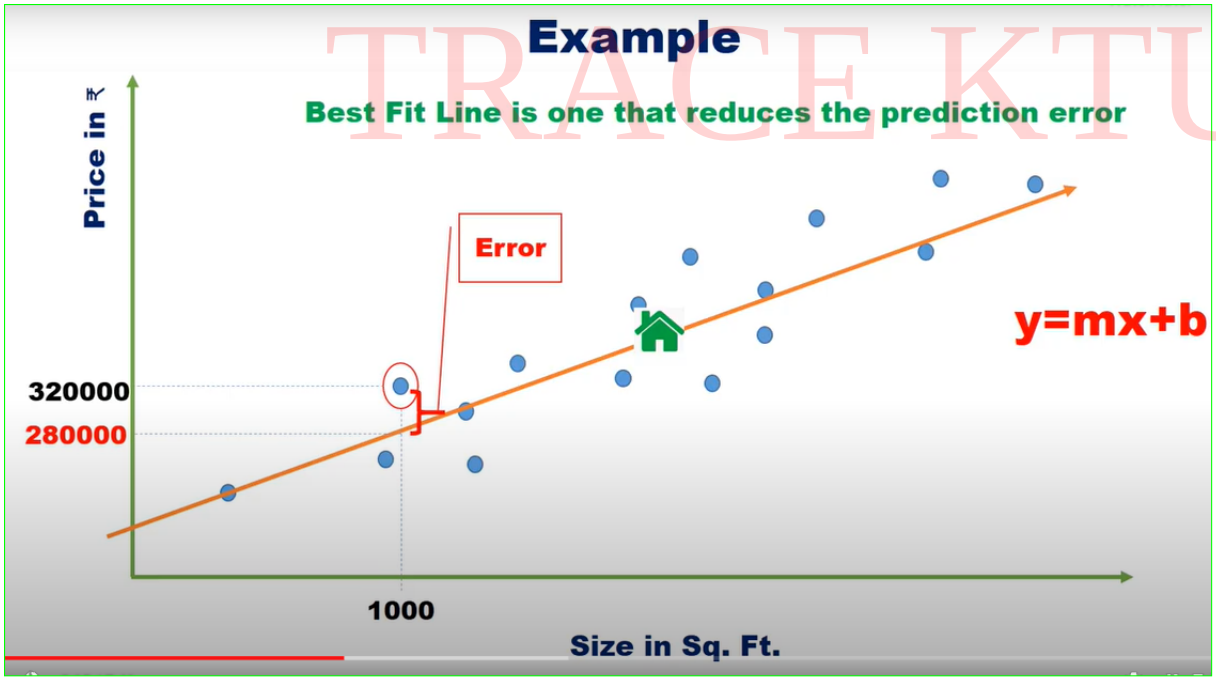

Price ???
1500 Sq Ft


Example
260 Sq. Ft.
Price :₹13,000/-
1500 Sq Ft
Price ???
2200 Sq. Ft.
Price :₹85,000/-
100 Sq. Ft.
rice :₹10,000/-
400 Sq. Ft.
Price :₹30,000/-
750 Sq. Ft.
Price :₹75,000/-
2600 Sq. Ft.
Price :₹90,000/-
3000 Sq. Ft.


Example
Price in ₹
Size in Sq. Ft.


Example
Predicted Price :
48 lakhs
Price in ₹
80000
1500
Size in Sq. Ft.


Best Fit Line is one that reduces the prediction error
Price in ₹
y=mx+b


Example
Best Fit Line is one that reduces the prediction error
Price in ₹
Error
y=mx+b
320000
280000
1000
Size in Sq. Ft.

- Learning associations
  - Association rule learning:
    - is a machine learning method for discovering interesting relations, called **“association rules”,** between variables in large databases using some measures of **“interestingness”.**

  - **Example Consider a supermarket chain.**
  - **The management of the chain is interested in knowing whether there are any patterns in the purchases of products by customers like the following:**
    - **“If a customer buys onions and potatoes together, then he/she is likely to also buy hamburger.”**

- Customer behaviour,
  - this defines an association between the set of products {onion, potato} and the set {burger}.
  - This association is represented in the form of a rule as follows:
  - {onion, potato} ⇒ {burger}
  - The measure of how likely a customer, who has bought onion and potato, to buy burger also is given by the conditional probability
    - P({onion, potato}|{burger}).
  - If this conditional probability is 0.8,
  - then the rule may be stated more precisely as follows: “80% of customers who buy onion and potato also buy burger.”

Learning associations

- **How association rules are made use of:**

- Consider an association rule of the form

X => Y,

that is, if people buy X then they are also likely to buy Y .

- Suppose there is a customer who buys X and does not buy Y .
- Then that customer is a potential Y customer.
- Once we find such customers, we can target them for cross-selling.

A knowledge of such rules can be used for promotional pricing or product placements.

Learning associations

- General case

- We are interested in learning a **conditional probability** of the form **P(Y|X)** where Y is the product the customer may buy and X is the product or the set of products the customer has already purchased.

  - If we may want to make a distinction among customers, we may estimate **P(Y|X,D)** where D is a set of customer attributes, like gender, age, and so on,

Learning associations

- There are several algorithms for generating association rules. Some of the well-known algorithms are listed below:
  - Apriori algorithm
  - Eclat algorithm
  - FP-Growth Algorithm (FP stands for Frequency Pattern)

Regression	Classification

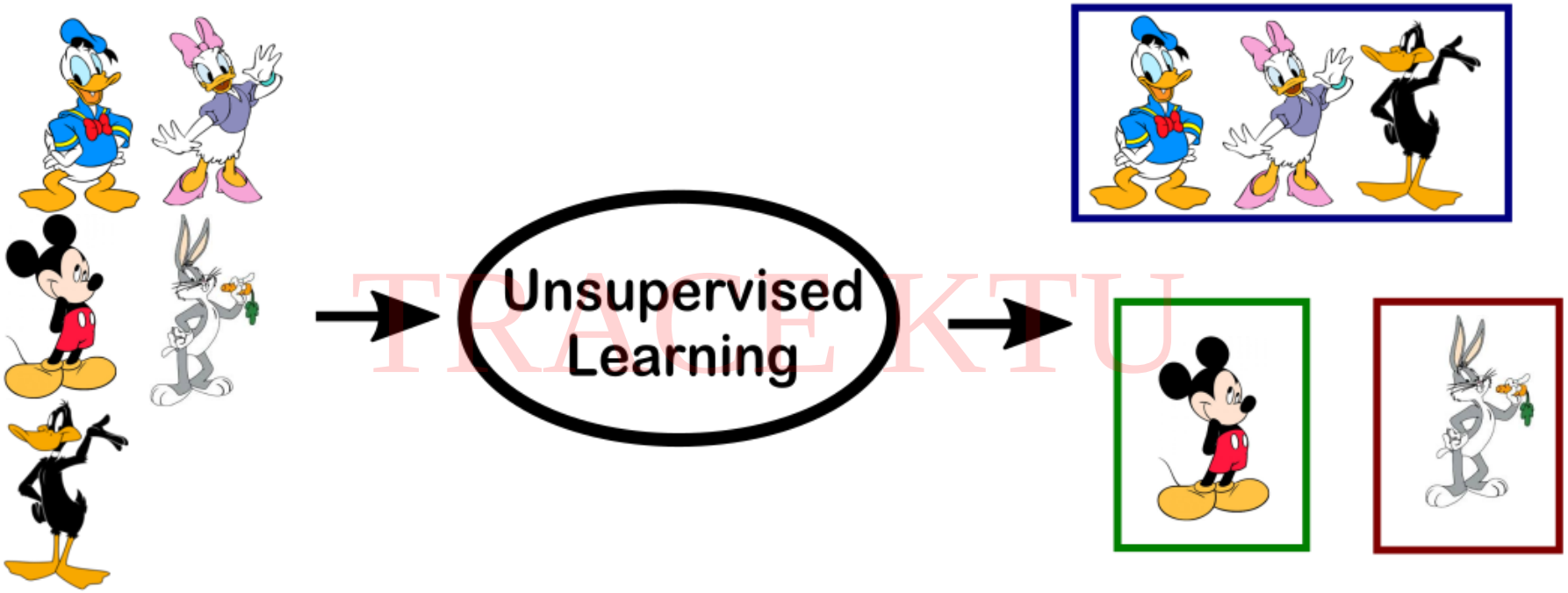
• Regression is used to predict **continuous values**.
 	
• Examples – once a model is trained based on sample data
 	
  ○ Predicting price of a house given the area, no of bedrooms
  ○ Predicting amount of rainfall given temperature, humidity etc
 	
Draw regression figure, and explain the above example of predicting price of car
	• Classification is used to predict which class a data point is part of (**discreet value**)
	  • Example –
	
	  ○ Classifying mail as spam or not spam
	  ○ Identifying a fruit based on size, color, length , diameter etc
	  ○ Identifying if a tumor is begin or malignant
	
	Draw Classification figure and explain the bank credit rating based on income and savings example

Both regression and classification are *supervised learning* problems where there is an input, X, an output, Y, and the task is to learn the mapping from the input to the output. $y = g(x\|\theta)$, where $g(\cdot)$ is the model and θ are its parameters. ***Y* is a number in regression and is a class code (e.g., 0/1) in the case of classification.** ***g(·)* is the regression function and in classification, it is the discriminant function separating the instances of different classes.**	

Unsupervised Learning

- Training of machine using information that is neither classified nor labeled and allowing the algorithm to act on that information without guidance.
- Here the task of machine is to group unsorted information according to similarities, patterns and differences without any prior training of data.(cluster Analysis)
- Unsupervised Learning is a type of machine learning algorithm used to draw inferences from datasets consisting of input data without labelled responses.

Unsupervised Learning



Exercise 1

Supervised Learning

No.	SIZE	COLOR	SHAPE	FRUIT NAME

Supervised Learning

No.	SIZE	COLOR	SHAPE	FRUIT NAME
1	Big	Red	Rounded shape with depression at the top	Apple
2	Small	Red	Heart-shaped to nearly globular	Cherry
3	Big	Green	Long curving cylinder	Banana
4	Small	Green	Round to oval,Bunch shape Cylindrical	Grape

Unsupervised Learning

- Suppose you have a basket and it is filled with some different types of fruits and your task is to arrange them as groups.
- This time, you don't know anything about the fruits, You have no clue about those.
- So, how will you arrange them?
- What will you do first???
- You will take a fruit and you will arrange them by considering the physical character of that particular fruit.

Unsupervised Learning

- Suppose you have considered color.
  - Then you will arrange them on considering base condition as color.
  - Then the groups will be something like this.
    - RED COLOR GROUP: apples & cherry fruits.
    - GREEN COLOR GROUP: bananas & grapes.
- So now you will take another physical character such as size.
  - RED COLOR AND BIG SIZE: apple.
  - RED COLOR AND SMALL SIZE: cherry fruits.
  - GREEN COLOR AND BIG SIZE: bananas.
  - GREEN COLOR AND SMALL SIZE: grapes.

Unsupervised Learning

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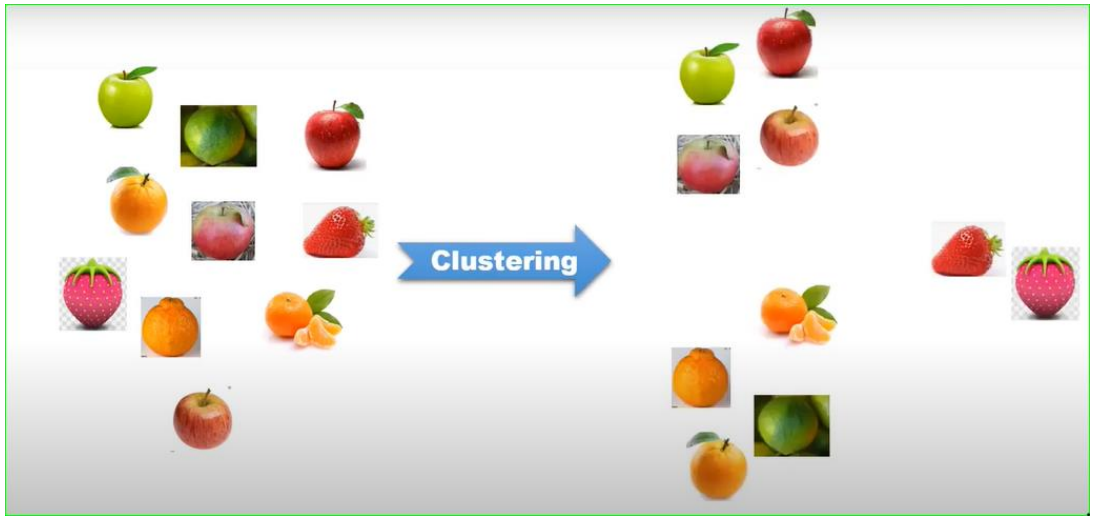
  - GREEN COLOR AND BIG SIZE: bananas.
  - GREEN COLOR AND SMALL SIZE: grapes.

Unlabelled Examples

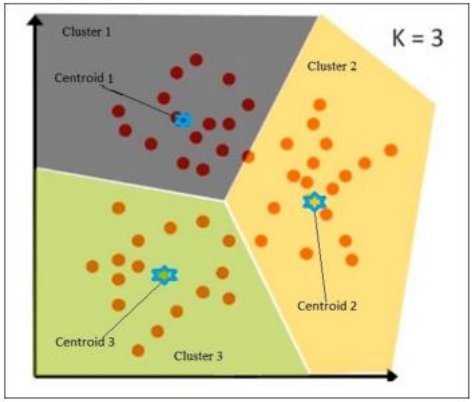
Weight	Texture
140g	Smooth
130g	Smooth
150g	Rough
135	Smooth
170g	Rough
180g	Rough



- Clustering has a large no. of applications spread across various domains.

Some of the most popular applications of clustering are:

- Recommendation engines
- Market segmentation
- Social network analysis
- Search result grouping
- Medical imaging
- Image segmentation
- Anomaly detection



Supervised Learning	Unsupervised Learning
1. Supervised learning is where you have input variables (x) and an output variable (Y) and you use an algorithm to learn the mapping function from the input to the output. $Y = f(X)$ The goal is to approximate the mapping function so well that when you have new input data (x) you can predict the output variables (Y) for that data.	1. Unsupervised learning is where you only have input data (X) and no corresponding output variables. The goal for unsupervised learning is to model the underlying structure or distribution in the data in order to learn more about the data.
2. It is called supervised learning because the process of an algorithm learning from the training dataset can be thought of as a teacher supervising the learning process. We know the correct answers, the algorithm iteratively makes predictions on the training data and is corrected by the teacher. Learning stops when the algorithm achieves an acceptable level of performance.	2. These are called unsupervised learning because unlike supervised learning above there is no correct answers and there is no teacher. Algorithms are left to their own devises to discover and present the interesting structure in the data.
3. Supervised learning problems can be further grouped into regression and classification problems.	3. Unsupervised learning problems can be further grouped into clustering and association problems.
4. Explain regression/classification technique as example with figure	4. Explain Clustering technique with example figure

Reinforcement Learning

- A type of Machine Learning algorithms which allows an agents/ machines learns how to behave in an environment by performing certain actions and by observing the rewards it gets from those actions.
  - automatically determine the ideal behavior within a specific context, to maximize its performance.
- A reinforcement learning algorithm, or agent, learns by interacting with its environment.
- The agent receives rewards by performing correctly and penalties for performing incorrectly.
- The agent learns without intervention from a human by maximizing its reward and minimizing its penalty.

Environment is the setting where the agent exists and operates

In Reinforcement learning scenario there is a decision maker, called the ***agent***, that is placed in an ***environment***. At any time, the environment is in a certain ***state*** .The decision maker has a set of ***actions*** possible. Once an action is chosen and taken, the state changes. The solution to the task requires a sequence of actions, and we get feedback, in the form of a ***reward***. The learning agent learns the best sequence of actions to solve a problem where "best" is quantified as the sequence of actions that has the maximum cumulative reward. Such is the setting of *reinforcement learning*.

Reinforcement Learning

- Consider an example of a child learning to walk.
  - child will **observe** how you are walking.
  - Soon he/she will understand that before walking, the child has to stand up
  - now the child **attempts to get up**, staggering and slipping
  - Standing up was easy, but to **remain still** is another task
  - Now the real task for the child is to start walking.
  - But it's easy to say than actually do it.
  - There are so **many things to keep in mind**, like balancing the body weight, deciding which foot to put next and where to put it.

Reinforcement Learning Cont..

- the “problem statement” of the example is **to walk**, where **the child is an agent** trying to manipulate the **environment** (which is the surface on which it walks) by **taking actions** (viz walking) and he/she tries to go from one **state** (viz each step he/she takes) to another.

- The child gets a **reward** (let’s say chocolate) when he/she accomplishes a **submodule of the task** (viz taking couple of steps) and will not receive any chocolate (**negative reward**) when he/she is not able to walk.
- Robotics and Game

- A good example is game playing where a single move by itself is not that important; it is the sequence of right moves that is good.
  - A move is good if it is part of a good game playing policy.
- A robot navigating in an environment in search of a goal location is another application area of reinforcement learning.
  - At any time, the robot can move in one of a number of directions.
  - After a number of trial runs, it should learn the correct sequence of actions to reach to the goal state from an initial state, doing this as quickly as possible and without hitting any of the obstacles.
- Other examples include
  - Adaptive Traffic signal optimization
  - Adaptive power grid

- The mathematical framework for defining a solution in reinforcement learning scenario is called Markov Decision Process.
- This can be designed as:
  - • Set of states, S
  - • Set of actions, A
  - • Reward function, R
  - • Policy, π
  - • Value, V
- We have to take an action (A) to transition from our start state to our end state (S).
- In return getting rewards (R) for each action we take.
- Our actions can lead to a positive reward or negative reward. The set of actions we took define our policy (π) and the rewards we get in return defines our value (V). Our task here is to maximize our rewards by choosing the correct policy.

Semi-supervised learning

- Its an approach to machine learning that combines a small amount of labeled data with a large amount of unlabeled data during training.
- Semi-supervised learning falls between unsupervised learning (with no labeled training data) and supervised learning (with only labeled training data).
- It is a special instance of weak supervision.
- Unlabeled data, when used in conjunction with a small amount of labeled data, can produce considerable improvement in learning accuracy.
- The acquisition of labeled data for a learning problem often requires a skilled human agent (e.g. to transcribe an audio segment) or a physical experiment (e.g. determining the 3D structure of a protein or determining whether there is oil at a particular location).

- Practical applications of Semi-Supervised Learning

  1. Speech Analysis: Since labeling of audio files is a very intensive task, Semi Supervised learning is a very natural approach to solve this problem.

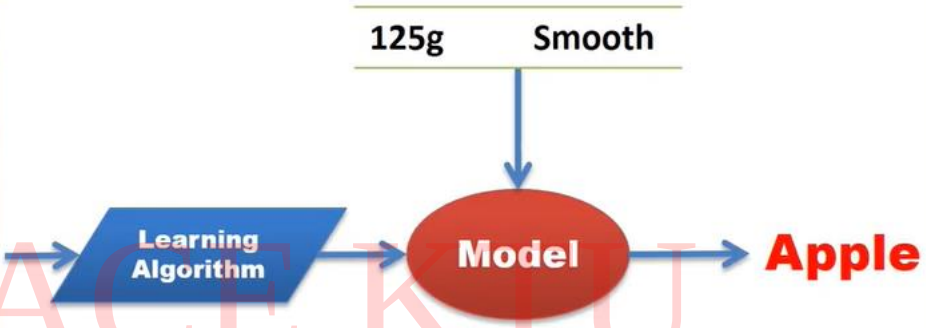
  2. Internet Content Classification: Labeling each webpage is an impractical and unfeasible process and thus uses Semi-Supervised learning algorithms.

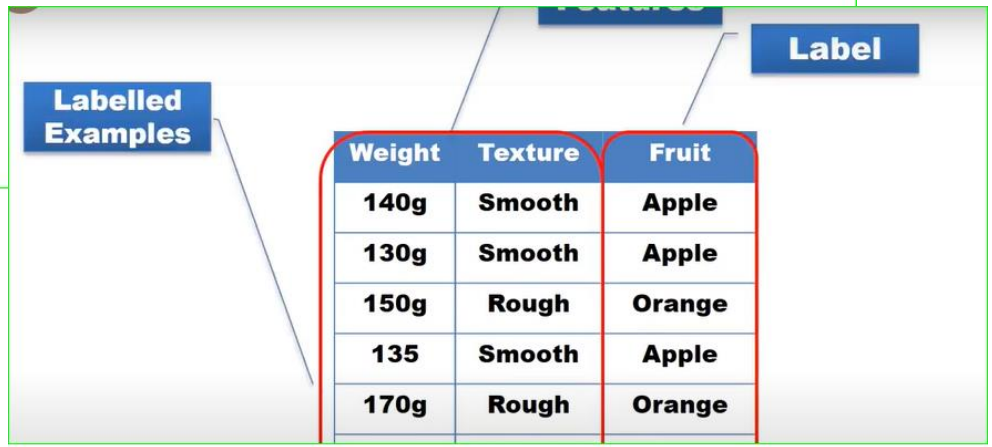
  Even the Google search algorithm uses a variant of Semi-Supervised learning to rank the relevance of a webpage for a given query

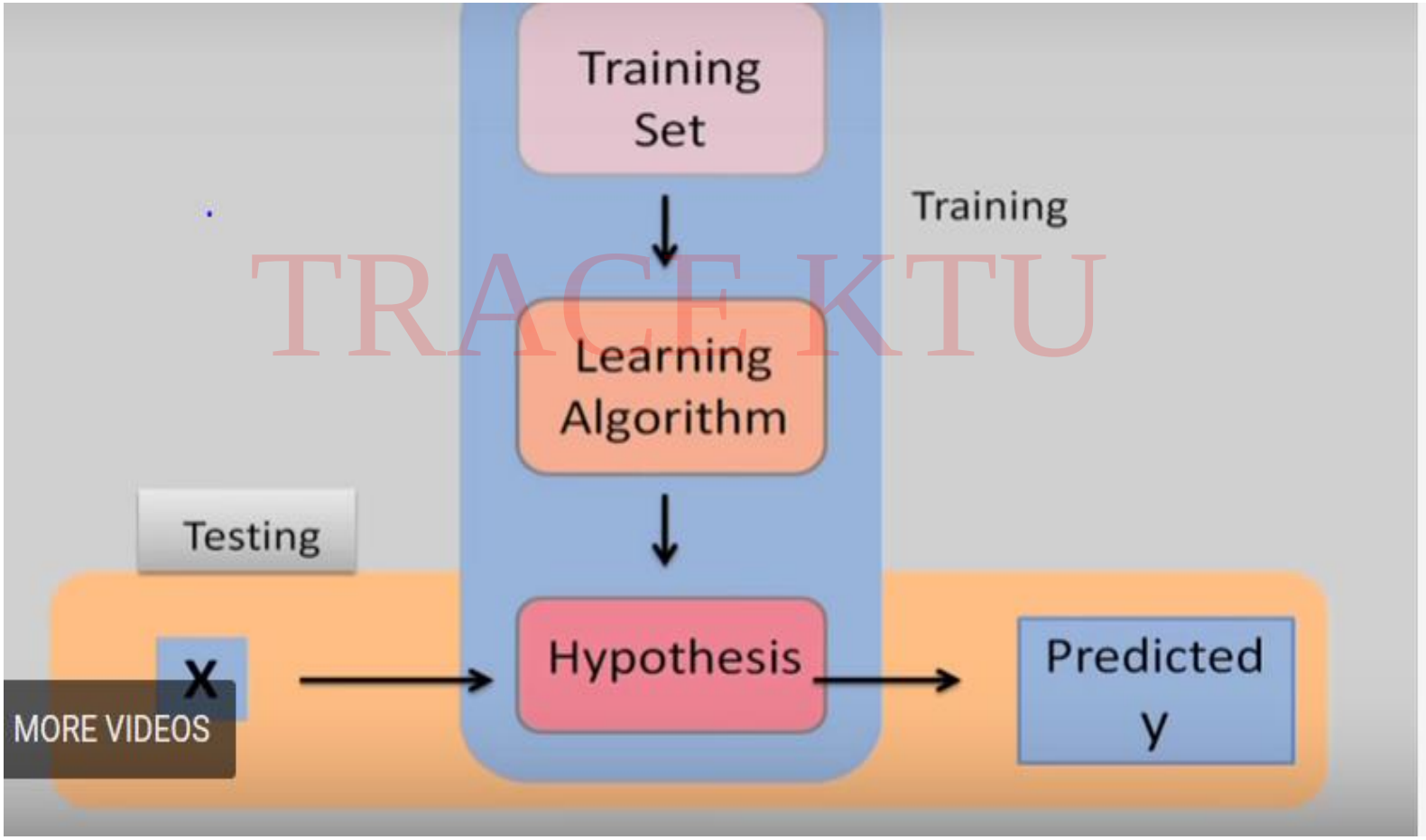
Fruit Example:Supervised

Label/Target

Weight	Texture	Fruit
140g	Smooth	Apple
130g	Smooth	Apple
150g	Rough	Orange
135	Smooth	Apple
170g	Rough	Orange
180g	Rough	Orange
110g	Smooth	Apple
155g	Rough	Orange






Training Set
Training
Learning Algorithm
Testing
Hypothesis
Predicted y
x
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