UNIT-1

- → ML → types
  → perspective
  → issues
- → Supervised Learning
- → the brain and Neuron
- → Design a learning Machine
- → Concept learning → Task
  → as Search
- → Finding a Maximally Specific Hypothesis [Find-S] Algorithm

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- → Linear Discriminants → Perceptron
  → Linear separability
  → Linear regression

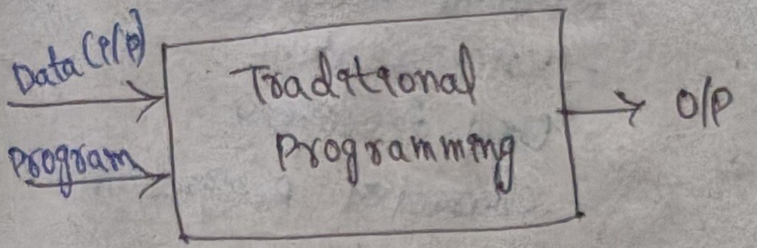
Machine Learning

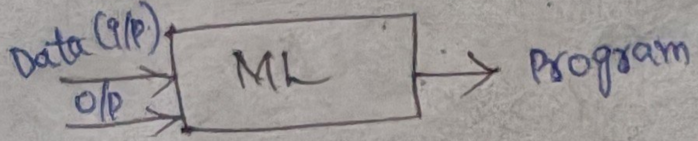
→ ML is a subset of AI
  - which uses algorithms
  - that learn from data to make Predictions.

→ Machine is learning from data & Past experience.

→ Arthur Samuel used the term ML in 1959.

→ It improves Performance from experience.





Features:

→ ML uses data to detect various Patterns.

→ It can learn from Past data & improve automatically.

→ ML is similar to Data mining.
  - as it also deals with huge amount of data.

→ ML learns from historical data
  - builds the Prediction models
  - & whenever it receives new data, predicts the o/p.

→ The accuracy of Predicted o/p depends upon the amount the data

→ If data is huge, it predicts o/p more accurately

Why ML now?

1. Lot of available data
2. Increasing computational power (GPU, TPU)
3. Advanced Algorithms.
4. Increasing support from Industries.

Applications

- Traffic Alerts
- Social Media
- Product Recommendation.
- Self Driving cars
- Google Translate
- Dynamic Pricing
- Virtual Personal Assistants (Alexa, Siri ...)
- Netflix
- blackbox.ai
- Facial Recognition
- Voice assistant
- Drug discovery
- Character Recognition.

Types of ML — Supervised Learning
— Unsupervised Learning
— Semi-Supervised Learning
— Reinforcement Learning

1. Supervised Learning: → It is a type of ML.
→ It learns from labeled data
→ uses labeled data to predict outcomes
→ model learns from labeled data
- where the I/O pairs are known.

Types: 1. Regression: Predicting continuous values
→ output is numeric value.
Ex: house prices, temperature.
2. Classification: Predicting categorical outcome
Ex: Spam detection, Pass or Fail
→ O/P is category or label

Algorithms
- Linear Regression
- Logistic Regression
- Decision Trees
- Support Vector Machines (SVM)
- K-Nearest Neighbors (KNN)
- Neural Networks

* Labeled data -
I/P & O/P both are known

Real-life Examples
- Email Spam detection
- Weather Prediction
- Loan approval
- Face recognition
- Predicting exam results

→ It uses labeled data.
→ Computer learns from examples
- & make predictions
ex: I/P: 2 hours studied
O/P: Fail
I/P: 6 hours studied
O/P: Pass
→ After learning, model can Predict O/P for new inputs

ex: I/P: 1 hour studied
O/P: Fail

2. Unsupervised learning → It is a type of ML

→ Model learns from unlabel data.

→ It uses unlabeled data to find patterns or relationships.

Types:
- clustering
- Dimensionality Reduction

→ It uses unlabeled data (i/p is given, no o/p)

→ there is no teacher during training.

→ The goal is to group, simplify, organize data.

1. clustering

→ Grouping similar data points.

ex: grouping students by marks.

2. Dimensionality Reduction

→ Simplifying data
- by reducing feature.

ex: Isomap, PCA

(with answers)
• Supervised = Labeled data
• Unsupervised = Unlabeled data (no answers)

Algorithms

→ K-means clustering.

→ DBSCAN

→ Hierarchical clustering

→ PCA

* Semi-Supervised ML

→ It is a type of ML

→ It uses both labeled & unlabeled data for training.

→ It falls b/w supervised learning & unsupervised learning.

Common Algorithms:

→ Self-training

→ Co-training

→ Graph-based methods

→ Generative models

Applications

→ Speech ~~reg~~ recognition

→ Medical diagnosis

→ Fraud detection

Ex: Imagine you have 1000 handwritten digit images.

- but only 100 are labeled
- A semi-supervised model learns from these 100 labeled images.
- And then applies, what it learned to classify the remaining 900 unlabeled images.

* Reinforcement Learning (RL)
→ follows trial-&-error approach
→ No need for labeled data.

→ An agent learns by interacting with an environment.
- & receives rewards or penalties.

→ The goal is to maximize the total reward over time.

Types

1. **Model-Free RL**: The agent learns purely from experience.
2. **Model-Based RL**: The agent builds a model of the environment.

Applications of RL

→ Robotics
→ Gaming
→ Finance
→ Health care
→ Self-Driving cars

Ex:

→ Imagine training a dog
- If the dog sits when commanded, it gets a treat (reward)
- If it jumps instead, no treat (Penalty)

-

Key concepts

- Agent : Learner/decision maker
- Environment : World around agent
- Actions : What agent can do
- Reward : +ve or -ve feedback

→ output depends on action, state
→ It is a type of ML.
State - current situation

* Perspectives & issues in ML

~~Rep.~~

• **Perspectives**

→ Perspective means a way of looking at something.

→ It means a way of understanding something.

→ A perspective in ML is a way of explaining or understanding how ML works, such as:

- As a function
- As optimization
- As model
- As recognizing patterns
- As generalization
- As pb predaction.

→ ML can be seen in different ways
- depending on the goal,

→ Each perspective explains ML from a different angle.

→ In ML, it means how we understand or explain what ML is doing.

→ In ML, perspectives are different ways to explain how ML works.

→ It is like looking at one thing from different angles.

Examples

→ One Person sees ML as finding a formula (function)

→ Another sees it as reducing error (optimization)

→ Another Sees it as finding Patterns.

⇒ All are correct.

⇒ they are just different Perspectives.

⇒ These perspectives help us to understand & improve ML model.

- Issues

1. overfitting
2. Underfitting
3. Not Enough Data
4. Noisy data
5. Privacy
6. Lack of Quality Data
7. Computational cost
8. Scalability
9. Evaluation
10. Security

1. Scalability

→ When data becomes huge, algorithms fail or slow down.

2. Evaluation

→ Measuring a model's performance is not always easy.

3. Not enough Data : Insufficient data

→ Less data = Poor learning.

4. Privacy

- Using Personal data may be risky.

* The Brain & the Neuron

→ In AI & ML, artificial neural n/ws (ANNs) are designed to mimic the way biological neurons process info

→ ANNs consist of layers of artificial neurons
- that receive input
- process it
- generate o/p
- similar to how real neurons work in the brain

→ Human brain & neurons inspire ANNs

→ ANN is foundation of deep learning

~~Biological Neuron v/s AN~~

Layers in ANNs

Input layer : Receives data

Hidden Layer : Perform computations

O/p layer : Produces final decision or prediction

Applications

→ Computer vision

→ NLP

→ Healthcare

→ Autonomous Systems

→ The human brain inspired ANN in ML.

Biological neurons

⇒ Also called nerve cell

⇒ neuron processes & transmits info using electrical signals

⇒ It consists of:

- Dendrites
- cell body
- Axon
- Synapses

Artificial Neuron

⇒ Also called Perceptron

→ neuron process info using mathematic fns

⇒ It consists of

- Inputs
- weights
- Σ f^n
- Activation f^n
- O/P

- Input $(x_1, x_2, \ldots x_n)$ – receive data
- weights $(w_1, w_2, \ldots w_n)$ – tells the importance of i/p
- Σ f^n: combines the inputs using weights
- Activation F^n: Decides whether the neuron should "fire" (pass info forward)
- O/P: final result p
  i.e passed to next neuron / layer

* Designing a Learning System

→ To get a successful learning system, it should be designed.

→ For a proper design, several steps should be followed.

Steps

1. Choosing the training experience.
2. Choosing the target function.
3. Choosing a representation for target function.
4. Choosing a learning algorithm for approximating the target function.

→ final design is obtained

* Designing a Learning System

→ A learning System is a computer program
- that can learn from experience
- & make decisions or predictions

⇒ Designing a learning system means creating a ML model to
- that can learn from data
- & make good decisions on its own

⇒ LS is a Part of ML

Steps

1. **Define the problem:** - what is the actual issue

→ Decide what you want the model to do
→ what do you want to predict or decide?

eg: Predict house prices, detect spam, Predict Student marks

2. **Collect Data:** Gather real-world data related to problem

→ Gather useful data
- from sources like websites, sensors, ~~APPS~~ databases. eg: Previous exam scores, attendance, study hours

3. **Preprocess data:**

→ Clean the data, remove errors
& format it properly. Eg: remove blanks, convert marks to numbers

4. **Choose an Algorithms**

→ Pick a suitable ML model
(eg: Decision Tree, KNN)

5. **Train the Model:** Teach the model using training data. → Give data to model to learn

6. **Evaluate Performance:** Test the model to check how well it works.

Problem
↓
Data
↓
Preprocess
↓
Algo
↓
Train
↓
Test
↓
Use

- **Deploy the Model:** Use the model in a real-world appln
eg: Website or app
- **Monitor or Update:** Check regularly & improve the model as new data comes in

A learning system is a computer program that:
1. Takes data as i/p
2. Learns patterns from that data
3. Make Predictions or decisions
4. Gets better as it sees more data

~~Ex~~
Example Student
→ Student learn from books & give answers in test
→ A learning System learns from past data & gives results

Real-Life ex: • Youtube recommends videos based on what you watch • Google Maps, • Spam Filter

⇒ A LS is like a Student:
- It studies examples (data)
- Learns Patterns from them,
- & answers questions (make Predictions)

*Find S Algorithm

(Finding a maximally specific hypothesis)

→ This algorithm considers only positive examples.

→ Representations:

Most specific hypothesis — ϕ

Most general hypothesis — ?

→ We find maximally specific hypothesis.

Algorithm

Step-1: Initialize with most specific hypothesis (ϕ)

$$h_0 = < \phi, \phi, \phi, \phi, \phi >$$

Step-2: For each +ve sample,

for each attribute,

if (value = hypothesis value) then ignore.

else

Replace with the most general hypothesis (?)

Example	Color	Toughness	Fungus	Appearance	Poisonous
1.	Green	Hard	No	wrinkled	Yes
2.	Green	Hard	Yes	smooth	No
3.	Brown	soft	No	Wrinkled	No
4.	orange	Hard	No	wrinkled	Yes
5.	Green	soft	Yes	Smooth	Yes
6.	Green	Hard	Yes	wrinkled	Yes
7.	orange	Hard	No	wrinkled	Yes

→ Compare h_3 with next example.

$h_4 = \langle ?, ?, ?, ? \rangle$

Step-1: Consider most specific hypothesis

$h = \langle \phi, \phi, \phi, \phi \rangle$

Step-2: Compare h with first example as it is +ve.

$h = \langle$ Green, Hard, NO, Wrinkled $\rangle$

Step-3: No changes ~~to~~ be made (as it is -ve)

$h_1 = \langle$ Green, Hard, NO, Wrinkled $\rangle$

→ No changes to be made in h_2 (-ve)

$h_2 = \langle$ Green, Hard, No, Wrinkled $\rangle$

Step-4: Compare with 4th example (+ve)

$h_3 = \langle ?,$ Hard, No, Wrinkled $\rangle$

Step-5: Compare with 5th example (+ve)

$h_4 = \langle ?, ?, ?, ? \rangle$

* Concept learning

→ It is the process of teaching a machine
 - to recognize patterns based on given examples.

→ It is process of finding a hypothesis that best fits a given set of examples

Key components

1. Concept
2. Hypothesis Space(H)
3. Instances(X)
4. Training Examples
5. Target function

→ It is the task of deriving a general rule or concept from specific examples.

→ The aim is to find a hypothesis

→ Training examples consists of +ve (belongs to concept) & -ve example.

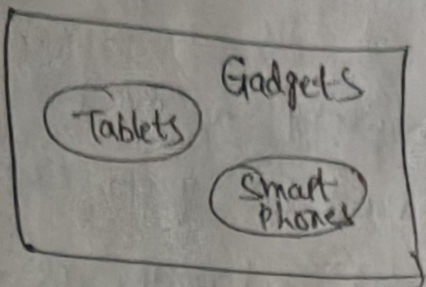
Challenges

- Over fitting
- Underfitting
- Noise Handling

Applications

→ Image recognition
→ Spam detection
→ object recognition
→ Medical diagnosis (predicting diseases from symptoms)

Ex:



consider a universe of Gadgets

→ We have many Gadgets, but now we are considering tablets, smart phones

→ Each & every gadget have its own features. called as "Binary valued attributes"

Features (Binary valued attributes)

Size: large, small → x_1

color: Blue, Black → x_2

Screentype: Flat, Folded → x_3

Shape: Square, Rectangle → x_4

→ concept is represented as

concept = $< x_1, x_2, x_3, x_4 >$

Tablet = < large, blue, Flat, Square >

Smart phone = < small, black, folded, Rectangle >

$\boxed{\text{* No. of possible instances} = 2^d} = 2^4 = 16$

- d = no. of features

* Total possible concepts = $2^{2^d} = 2^{16}$

→ We don't teach all 2^{16} concepts.

→ We will choose some from 2^{16}, received

→ only the concepts which are consistent, those will be choosen/considered.

→ If all are ϕ, then reject all.
- It is the most specific hypothesis

→ $\langle ?, ?, ?, ? \rangle$ → accept all
↳ It is most general hypothesis